SUBSTRATE PROCESSING APPARATUS AND SUBSTRATE PROCESSING METHOD

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to a substrate processing apparatus and a substrate processing method for applying processing to a surface (in particular, a peripheral portion) of a substrate. Substrates subject to processing include various kinds of substrates, such as a semiconductor wafer, a glass substrate for a liquid crystal display, a glass substrate for a plasma display panel, a substrate for an optical disc, a substrate for a magnetic disc, a substrate for a magneto-optical disc, and a substrate for a photomask.

Description of Related Art

The fabrication sequence of a semiconductor device occasionally includes processing that removes, through etching, an unwanted portion of a metal thin film, such as a copper thin film, formed across the entire main surface and peripheral end surface (and the back surface when needed) of a semiconductor wafer (hereinafter, referred to simply as the wafer). For example, because it is sufficient to provide a copper thin film used to form wirings to an element-forming region on the surface of the wafer alone, the copper thin film

formed on the peripheral portion of the surface (for example, a portion approximately 5 mm wide from the peripheral edge of the wafer), the back surface, and the peripheral end surface of the wafer is unnecessary. Moreover, copper or copper ions on the peripheral portion, the back surface, and the peripheral end surface raise a problem that they contaminate the hands of a substrate-transporting robot provided to a substrate processing apparatus, and such contamination is transferred to another substrate held by the contaminated hands.

Another processing is performed occasionally for the similar reason, by which metal contaminants (including metal ions) on the surfaces of films (silicon dioxide film, nitride film, etc.) other than the metal film formed on the substrate periphery are removed by slightly etching away these films.

A substrate periphery processing apparatus used to selectively etch away the thin film on the peripheral portion and the peripheral end portion of the wafer includes, for example, a spin chuck that rotates while holding a wafer horizontally, a blocking plate that limits a space on the wafer above the spin chuck, and an etching liquid supply nozzle that supplies etching liquid to the lower surface of the wafer. The etching liquid supplied to the lower surface of the wafer is forced outwards in the direction of the turning radius on the lower surface of the wafer by a centrifugal force, comes around the end surface of the wafer to the upper surface of the wafer,

and thereby etches away unwanted materials on the peripheral portion of the upper surface of the wafer. In this instance, the blocking plate is placed in close proximity to the upper surface of the wafer, and an inert gas, such as a nitrogen gas, is supplied to a space between the blocking plate and the wafer.

Because a quantity of the etching liquid coming around to the upper surface can be adjusted by adequately adjusting a flow rate of the inert gas and the rotational speed of the spin chuck, etching processing can be applied selectively to a region of a specific width (for example, 1 to 7 mm wide) in the peripheral portion of the upper surface of the wafer (so-called bevel etching processing).

By supplying the etching liquid to the wafer from the lower surface while the wafer is held and rotated by the spin chuck, unwanted materials on the peripheral portion of the upper surface of the wafer is removed through etching. Subsequently, deionized water rinsing processing is applied to both the upper and lower surfaces of the wafer followed by drying processing, by which the spin chuck is rotated at a high speed to throw off water droplets on the upper and lower surfaces.

According to the arrangement as described above, however, a quantity of the etching liquid coming around to the upper surface cannot be controlled precisely, which raises a problem that accuracy as to an etching width becomes so poor that the

etching width varies in all parts along the peripheral portion of the wafer.

To be more specific, when there is a considerable distance between the upper surface of the wafer and the blocking plate, the etching liquid does not come in contact with the blocking plate. Thus, a quantity of the etching liquid coming around to the upper surface of the wafer is too small to control precisely a quantity of the etching liquid coming around to the upper surface. Further, in this case, there is another problem that a communication space connecting a space between the upper surface of the wafer and the blocking plate to an external space is large enough to allow an atmosphere, scattered droplets, or a fog or vapor (so-called mist) of the etching liquid to enter a device-forming region at the central portion of the surface of the wafer from outside.

On the other hand, when there is a short distance between the upper surface of the wafer and the blocking plate, the etching liquid having come around to the upper surface of the wafer comes in contact with the lower surface (plane) of the blocking plate. Thus, a quantity of the etching liquid coming around to the upper surface is too large to control precisely a quantity of the etching liquid coming around to the upper surface.

As has been discussed, a quantity of the etching liquid coming around to the upper surface cannot be controlled

precisely in either case.

Further, for example, when there is a difference between the rotational speed of the wafer and the rotational speed of the blocking plate, an airflow between the wafer and the blocking plate is disturbed, which may possibly vary a quantity of the etching liquid coming around to the upper surface of the wafer.

Also, in the case of a substrate processing apparatus according to another related art, as is disclosed in Japanese Laid-open Patent Application No. 2002-75953, a wafer is rotated while being held almost horizontally, and in the mean time, the blocking plate is placed oppositely at a position in close proximity to the upper surface (device-forming surface) of the wafer. Then, the blocking plate is rotated about the rotational axis line of the wafer while the etching liquid is supplied to the upper surface of the blocking plate. The etching liquid is then forced to scatter diagonally downward from the periphery of the blocking plate by a centrifugal force induced by rotations of the blocking plate, and the etching liquid is thereby supplied to the peripheral portion of the upper surface of the wafer. The etching liquid supplied to the peripheral portion of the upper surface of the wafer is then forced to flow toward the periphery of the wafer by a centrifugal force induced by rotations of the wafer, and flows downward on the peripheral surface (end surface) of the

wafer from the periphery of the wafer. An unwanted metal thin film formed on the peripheral portion of the upper surface and the peripheral surface of the wafer is thus removed.

Even with the use of this related art, however, it is difficult to control accurately a width (etching width) of a region on the upper surface of the wafer, from which a metal thin film is to be removed. In other words, according to the arrangement to scatter the etching liquid on the upper surface of the blocking plate forcedly by a centrifugal force, it is difficult to fix a supply position of the etching liquid on the upper surface of the wafer, which may possibly vary the width of the region on the upper surface of the wafer, from which the metal thin film is to be removed.

In addition, in either of the foregoing related arts, the shape of the region (region subject to processing) on the upper surface of the wafer, to which processing is applied with the use of processing liquid, is limited to an annular shape, and the processing with the use of processing liquid cannot be applied to a region of any other shape.

On the other hand, according to the related art using the etching liquid that comes around the lower surface to the upper surface of the wafer, in a case where a wafer subject to processing is a wafer having a hydrophobic surface (for example, an impurity-undoped polysilicon wafer), there is a problem that the etching liquid supplied to the lower surface

of the wafer cannot come around to the upper surface of the wafer easily, and fails to remove a metal thin film formed on the peripheral portion of the upper surface of the wafer.

On the contrary, according to the arrangement to scatter the etching liquid on the upper surface of the blocking plate forcedly by a centrifugal force, the etching liquid can be supplied to the peripheral portion of the upper surface of the wafer regardless of whether the surface of the wafer is hydrophobic or hydrophilic. According to this arrangement, however, the supply position of the etching liquid on the upper surface of the wafer changes in response to slightest variance in the rotational speed of the blocking plate or a flow rate of the etching liquid supplied to the blocking plate. This makes it difficult to control the etching width on the upper surface of the wafer with accuracy.

SUMMARY OF THE INVENTION

It is therefore a first object of the invention to provide a substrate processing apparatus and a substrate processing method capable of controlling precisely a processing width in a peripheral portion of the surface of a substrate.

A second object of the invention is to provide a substrate processing apparatus and a substrate processing method capable of controlling a width or a shape of a region to be processed with the use of processing liquid on an upper surface of the

substrate with accuracy.

A third object of the invention is to provide a substrate processing apparatus and a substrate processing method capable of applying processing with the use of processing liquid to a region subject to processing of an arbitrary shape on the upper surface of the substrate.

A fourth object of the invention is to provide a substrate processing apparatus and a substrate processing method capable of applying processing with the use of processing liquid to a peripheral portion of a substrate even when the substrate has a hydrophobic surface as well as controlling a width of a region to be processed with the use of processing liquid in the peripheral portion of the substrate with accuracy.

A first aspect of a substrate processing apparatus of the invention is an apparatus that removes an unwanted material on a surface of a peripheral portion of a substrate through etching by supplying etching liquid to the surface of the peripheral portion. The substrate processing apparatus includes an etching liquid supplying mechanism that supplies the etching liquid to the peripheral portion of the substrate, and an annular member that has an inner periphery on or inside an outer periphery of the substrate and thereby defines a processing width to be processed by the etching liquid on the surface of the peripheral portion of the substrate.

According to this arrangement, the annular member is

placed so as to secure a certain gap with respect to the surface of the peripheral portion of the substrate. The annular member includes the inner periphery on or inside the outer periphery of the substrate, and thereby defines an etching processing width on the surface of the peripheral portion of the substrate.

The annular member may be placed in close proximity to the surface of the peripheral portion of the substrate while securing a certain gap such that allows the annular member to come in contact with a liquid film of the etching liquid formed on the surface of the peripheral portion. In this case, the etching liquid supplied from the etching liquid supplying mechanism forms a liquid film on the peripheral portion of the surface of the substrate. However, because the annular member comes in contact with the liquid film, the etching liquid is limited in the vicinity of the inner periphery of the annular member, which makes it possible to prevent the etching liquid from entering an inner region of the substrate. It is thus possible to apply etching processing to the peripheral portion of the substrate with an accurate processing width in a satisfactory manner.

The substrate may be a substrate of a nearly circular shape, such as a semiconductor wafer, or a substrate of a rectangular shape, such as a glass substrate for a liquid crystal display.

Because the inner periphery of the annular member forms

a shape corresponding to the outer periphery of the substrate, the inner periphery is of a nearly circular shape when a substrate of a nearly circular shape is processed, and of a rectangular shape when a substrate of a rectangular shape is processed.

The substrate processing apparatus may further include a substrate holding mechanism that holds the substrate from one surface side, and the annular member may be placed on the other surface side of the substrate.

According to this arrangement, the peripheral portion of the substrate can be processed by holding the substrate from one surface side by the substrate holding mechanism while placing the annular member on the other surface side.

For example, it may be arranged in such a manner that the substrate holding mechanism holds the substrate from below, and the annular member is placed in close proximity to the upper surface side of the substrate.

In this case, the etching liquid can be supplied to the peripheral portion of the substrate from the etching liquid supplying mechanism while the substrate is held at rest (in a non-rotating state or a low-speed rotating state (at a speed low enough to prevent the etching liquid from spilling over from the substrate)). In other words, a mound of the etching liquid can be placed on the peripheral portion of the substrate, so that the unwanted material on the peripheral portion of the

surface of the substrate is removed through etching by a mound of the etching liquid thus placed. Because the annular member operates to control a liquid film of a mound of the etching liquid so as not to enter an inner side of the substrate, an etching width can be defined with satisfactory accuracy.

A quantity of consumed etching liquid can be reduced markedly by applying processing to the peripheral portion by placing a mound of the etching liquid on the substrate. In particular, by adopting the arrangement that allows the annular member to come in contact with the liquid film, the etching liquid can be held stably in a gap between the annular member and the peripheral portion of the surface of the substrate. It is thus possible to control the etching liquid so as not to enter an inner side of the substrate or spill out from the substrate. Further, a quantity of consumed etching liquid can be reduced markedly.

The state expressed as "the substrate held at rest" means a state where the substrate is not rotating or moving, or a substantially equivalent state. To be more specific, a state equivalent to a state where the substrate is not rotating includes a state where the substrate on which is placed a mound of the etching liquid is rotated at a speed low enough to prevent the etching liquid from spilling out from the substrate by a centrifugal force. Also, a state equivalent to a state where the substrate is not moving includes a state where the substrate

is moved spatially (movement in a vertical, horizontal, or diagonal direction) at an accelerating speed low enough to prevent a mound of the etching liquid placed on the substrate from spilling over from the substrate by inertia.

The substrate may be a substrate of a nearly circular shape. In this case, it is preferable that the apparatus further includes a substrate rotating mechanism that rotates the substrate, and the inner periphery of the annular member is of a circular shape having an inside diameter equal to or smaller than a diameter of the substrate.

According to this arrangement, the substrate is a substrate of a nearly circular shape, and the substrate is rotated by the substrate rotating mechanism. For example, the substrate rotating mechanism may include a substrate holding mechanism that holds a substrate and a rotational driving mechanism that rotates the substrate holding mechanism.

It is preferable that the annular member is driven to rotate in sync with rotations of the substrate (that is, in the same rotational direction at the same rotational speed as the substrate). However, the annular member may be held at rest or rotated at a rotational speed different from the rotational speed of the substrate. When the annular member is driven to rotate in sync with the rotations of the substrate, the annular member may be driven to rotate synchronously by a rotational driving mechanism different from the rotational

driving mechanism described above. Alternatively, the annular member may be placed on the substrate holding mechanism, so that both the substrate holding mechanism and the annular member are rotated by the rotational driving mechanism described above.

It is preferable that the substrate processing apparatus is arranged in such a manner that the etching liquid is supplied to the peripheral portion of the substrate from the etching liquid supplying mechanism while the substrate is rotated by the substrate rotating mechanism.

According to this arrangement, the etching liquid is supplied to the peripheral portion of the substrate from the etching liquid supplying mechanism when the substrate is in a rotating state. In this instance, although a liquid film of the etching liquid is formed on the peripheral portion of the substrate, the annular member operates to control the liquid film of the etching liquid not to enter an inner region of the substrate.

It is preferable that the annular member includes a substrate-opposing surface that extends outwards from the inner periphery and opposes the surface of the peripheral portion of the substrate.

According to this arrangement, for example, a liquid film of the etching liquid can be brought into contact with the substrate-opposing surface, which allows the liquid film to

be present in a space between the substrate-opposing surface and the surface of the peripheral portion of the substrate. It is thus possible to form a stable liquid film of the etching liquid across the entire surface of the peripheral portion of the substrate in a reliable manner, and as a consequence, more reliable, homogeneous etching processing can be achieved.

By making the substrate-opposing surface as a plane nearly parallel to the surface of the peripheral portion of the substrate, a more stable liquid film of the etching liquid can be formed.

The substrate-opposing surface may be an inclined plane inclined to reduce an interval between the substrate-opposing surface and the substrate as heading toward the inner periphery.

The inclined plane may be a plane or a curved plane. When the annular member has an inner periphery of a nearly circular shape, the inclined plane may be a conical plane or a curved plane curved in a concave or convex shape with respect to the conical plane.

According to this arrangement, because the substrate-opposing surface is the inclined plane of a shape such that nears the substrate as it heads toward the inside of the substrate, not only can the etching liquid be introduced into a gap between the substrate-opposing surface and the surface of the peripheral portion of the substrate in a reliable

manner, but also entrance of the etching liquid into an inner region of the substrate can be prevented more effectively.

It is preferable that an outer periphery of the substrate-opposing surface is located outside the outer periphery of the substrate. According to this arrangement, for example, when the etching liquid is supplied from the surface of the substrate on the opposite side to the surface of the peripheral portion of the substrate, the etching liquid that comes around the end surface of the substrate can be trapped by the substrate-opposing surface in a satisfactory manner, and the etching liquid can be thereby introduced into a gap between the substrate-opposing surface and the surface of the peripheral portion of the substrate.

For example, when it is arranged in such a manner that the substrate is held almost horizontally and rotated about the rotational axis line passing through the center of the substrate while the annular member is placed on the upper surface side of the substrate, the etching liquid supplied on the lower surface side of the substrate is forced to flow on the lower surface of the substrate by a centrifugal force, and comes around the end surface to the peripheral portion of the upper surface of the substrate. In this instance, when the outer periphery of the substrate-opposing surface is located outside the outer periphery of the substrate, the etching liquid coming around the end surface of the substrate can be

trapped in a satisfactory manner, and can be thereby introduced to the peripheral portion of the upper surface of the substrate in a reliable manner.

It is preferable that the annular member includes a projection that protrudes from the substrate-opposing surface toward the substrate and thereby limits the etching liquid heading toward an inside of the substrate.

It is preferable that the projection is a continuous projection strip formed in the peripheral portion of the substrate along the entire circumference in line with the inner periphery of the annular member.

According to this arrangement, the operation of the projection can prevent a liquid film of the etching liquid from entering an inner region of the substrate in a more reliable manner. It is thus possible to further improve accuracy of the etching width.

It is preferable that the projection includes, on an outer side of the annular member, an etching liquid limiting surface composed of an inclined plane that heads toward an outside of the substrate as moving away from a surface of the substrate.

Because the projection includes the etching limiting surface composed of an inclined plane on an outer side of the substrate, the etching limiting surface conforms to a shape of droplets of the etching liquid. It is thus possible to

prevent the etching liquid from entering an inner region of the substrate in a more reliable manner.

It is preferable that the annular member includes a liquid discharge path that opens in the substrate-opposing surface and communicates with an external space of the annular member.

According to this arrangement, the etching liquid between the substrate-opposing surface and the surface of the peripheral portion of the substrate can be discharged to an external space of the annular member through the liquid discharge path.

To be more specific, when the surface of the peripheral portion of the substrate is processed while the substrate and the annular member are rotated, it is possible to pump out the etching liquid that forms a liquid film between the substrate-opposing surface and the substrate by exploiting a centrifugal force acting on the etching liquid coming inside the liquid discharge path. Thus, when the etching processing is performed while the etching liquid is supplied to a space between the substrate-opposing surface and the substrate continuously or intermittently, extra etching liquid in the space between the substrate-opposing surface and the substrate can be discharged through the liquid discharge path, and new etching liquid can be thereby supplied to the liquid film. It is thus possible to maintain the etching ability of the etching

liquid, which in turn reduces a processing time.

It is preferable that the liquid discharge path is provided to open in the vicinity of the inner periphery of the annular member. Alternatively, the liquid discharge path may be formed in the projection to open in the surface opposing the substrate. Further, it is preferable to set a rotational speed of the annular member higher than a rotational speed of the substrate holding mechanism in promoting discharge of the etching liquid through the liquid discharge path.

It is preferable that the etching liquid supplying mechanism includes a liquid dispense path made in the annular member and including a dispense port that opens in the substrate-opposing surface. According to this arrangement, the etching liquid can be supplied directly to a space between the substrate-opposing surface and the peripheral portion of the surface of the substrate in a reliable manner.

It is preferable that the etching liquid supplying mechanism includes a dispense port that opens in the substrate-opposing surface, a liquid-receiving portion that communicates with the dispense port, and a nozzle that supplies the liquid-receiving portion with the etching liquid. According to this arrangement, the etching liquid can be supplied directly to a space between the substrate-opposing surface and the surface of the peripheral portion of the substrate by supplying the etching liquid to the

liquid-receiving portion from the nozzle. Also, for example, even when the annular member is rotated, the etching liquid can be supplied by a simple arrangement.

To be more concrete, it is sufficient to arrange in such a manner that the annular member is placed so that the substrate-opposing surface opposes the substrate from above, and the liquid-receiving portion is formed in an upper surface of the annular member.

It is preferable that the etching liquid supplying mechanism includes a nozzle that supplies the etching liquid toward a surface of the substrate on an opposite side to a surface containing the surface of the peripheral portion.

According to this arrangement, the etching liquid is supplied to the surface of the substrate on the opposite side to the surface of the peripheral portion, which is a region to be processed, and the etching liquid thus supplied is introduced to the surface of the peripheral portion by coming around the end surface of the substrate, which allows the etching liquid to form a stable liquid film with the annular member in a concerted manner.

In order to introduce the etching liquid supplied to the surface on the opposite side to the surface of the peripheral portion, it is preferable to rotate the substrate, so that the etching liquid supplied from the nozzle is introduced to the end surface of the substrate by a centrifugal force. Also,

when the substrate is a circular substrate, the etching liquid can be supplied to the surface of the peripheral portion of the substrate in a more satisfactory manner.

The nozzle may supply the etching liquid toward a central portion of the surface on the opposite side or it may supply the etching liquid toward the vicinity of the peripheral portion of the surface on the opposite side.

The etching liquid supplying mechanism may include a nozzle that supplies the etching liquid toward an outer wall surface of the annular member. According to this arrangement, the etching liquid is introduced to the peripheral portion of the surface of the substrate by flowing on the outer wall surface of the annular member to form a liquid film.

The etching liquid supplying mechanism may include a dispense port through which the etching liquid is dispensed in one of a direction perpendicular to a surface of the substrate and a direction inclined toward an outside of the substrate.

It is preferable that the annular member includes an inner wall surface that rises from the inner periphery in a direction to go away from a surface of the substrate.

According to this arrangement, it is possible to prevent a liquid film of the etching liquid from entering an inner region of the substrate further from the vicinity of the inner wall surface of the annular member in a reliable manner. The

inner wall surface may be a plane along a vertical direction or an inclined plane inclined with respect to a horizontal direction.

It is preferable that the inner wall surface is an inclined plane that heads toward a center of the substrate as moving away from the surface of the substrate.

According to this arrangement, when a liquid film of the etching liquid tries to move toward the inside of the substrate by surmounting the inner wall surface of the annular member, the liquid film is introduced to the inner wall surface side of the annular member, and as a consequence, fails to head to an inner region of the substrate. It is thus possible to control more precisely a region where a film of the etching liquid is present. In particular, when the annular member is rotated, even if the etching liquid tries to head toward the inside of the substrate by flowing on the inner wall surface, the etching liquid is forced back toward the outside of the substrate by a centrifugal force and gravity. This arrangement can thus prevent the etching liquid from entering an inner region of the substrate more effectively.

It is preferable that the substrate processing apparatus further includes a lid member that substantially clogs an internal space of the annular member.

According to this arrangement, droplets or mist of the etching liquid present in an external space of the annular

member will not reach the central region of the substrate by passing through the annular member. The surface of the peripheral portion can be thus processed in a satisfactory manner without giving any damage to the central region of the substrate. Moreover, because the liquid film seals a space between the annular member and the surface of the peripheral portion of the substrate, there is no possibility that droplets or mist in the exterior of the annular member will reach an inner region of the substrate by passing through a gap between the annular member and the surface of the peripheral portion of the substrate. An inner region of the substrate can be thus protected in a reliable manner.

The lid member may be formed integrally with the annular member or may be a separate member from the annular member.

It is preferable that the annular member includes an annular groove formed adjacently inside the inner periphery. According to this arrangement, because the etching liquid is not allowed to reach the central region of the substrate by passing through the annular groove, accuracy of the etching width can be improved further.

It is preferable that the substrate processing apparatus further includes a gas supplying mechanism that supplies an internal space of the annular member with a gas. According to this arrangement, it is possible to prevent a liquid film or droplets of the etching liquid from reaching an inner region

of the substrate in a more reliable manner.

It is preferable that the annular member includes an inner wall surface that rises from the inner periphery in a direction to move away from a surface of the substrate, and the gas supplied from the gas supplying mechanism is supplied toward the inner wall surface.

According to this arrangement, when a gas is supplied toward the inner wall surface of the annular member, the gas flows on the inner wall surface of the annular member toward the surface of the peripheral portion of the substrate. This prevents a liquid film of the etching liquid from being introduced to the central region of the substrate in a more reliable manner.

It is preferable that the annular member includes a gas flowing path that allows a communication between an internal space and an external space of the annular member.

According to this arrangement, a pressure difference between the inside and the outside of the annular member can be controlled by allowing a gas to flow between the inside and the outside of the annular member through the gas flowing path. This prevents an unwanted event that an internal pressure of the annular member rises above an external pressure to the extent that breaking occurs in a liquid film of the etching liquid formed on the surface of the peripheral portion of the substrate. It is thus possible to apply etching processing

to the peripheral portion of the substrate along the entire circumference in a satisfactory manner.

This arrangement is particularly effective when the lid member substantially clogs an internal space of the annular member.

It is preferable that the substrate processing apparatus further includes a protection liquid supplying mechanism that supplies etching protection liquid toward a center of the substrate at an inner side of the annular member. According to this arrangement, because the etching protection liquid can protect the central portion of the substrate, damages to the central region of the substrate can be prevented in a more reliable manner.

The etching liquid protection liquid may be, for example, deionized water, carbonated water, hydrogenated water, reduced water, ionized water, a magnetized water, etc.

A first aspect of a substrate processing method of the invention is a substrate processing method of removing an unwanted material on a surface of a peripheral portion of a substrate through etching by supplying etching liquid to the surface of the peripheral portion. The method includes a step of placing a mound of the etching liquid on the surface of the peripheral portion of the substrate while the substrate is held at rest, and a step of placing an annular member, having an inner periphery on or inside an outer periphery of the substrate,

in close proximity to the surface of the peripheral portion of the substrate and thereby defining a processing width to be processed by the etching liquid on the surface of the peripheral portion of the substrate.

A second aspect of the substrate processing method of the invention includes: a step of performing, in parallel, (a) a substrate rotating step of rotating the substrate, and (b) an etching liquid supplying step of supplying the etching liquid to the surface of the peripheral portion of the substrate being rotated; and a step of placing an annular member, having an inner periphery on or inside an outer periphery of the substrate, in close proximity to the surface of the peripheral portion of the substrate and thereby defining a processing width to be processed by the etching liquid on the surface of the peripheral portion of the substrate.

It is preferable that the etching liquid supplying step includes a step of supplying the etching liquid toward a surface of the substrate on an opposite side to a surface containing the surface of the peripheral portion.

It is preferable that the annular member is placed in close proximity to the surface of the peripheral portion of the substrate while securing a certain gap such that allows the annular member to come in contact with a liquid film of the etching liquid formed on the surface of the peripheral portion of the substrate.

It is preferable that the method further includes a gas supplying step of supplying an internal space of the annular member with a gas.

It is preferable that the method further includes a protection liquid supplying step of supplying etching protection liquid to a central region of the substrate at an inner side of the annular member.

A second aspect of the substrate processing apparatus of the invention is a substrate processing apparatus that applies processing to a peripheral portion of a substrate with the use of processing liquid. The substrate processing apparatus includes: a substrate holding mechanism that holds the substrate almost horizontally and rotates the substrate about a nearly vertical rotational axis line; an opposing member that includes a substrate-opposing surface opposing an upper surface of the substrate held by the substrate holding mechanism and having a hydrophobic property at least in a peripheral portion region, and a hydrophilic upper surface inclined to near an end edge of the substrate-opposing surface as heading downward, the opposing member protecting a central portion of the upper surface of the substrate by brining the substrate-opposing surface in close proximity to the upper surface of the substrate; and a processing liquid supplying mechanism that supplies the processing liquid to the upper surface of the opposing member.

According to the above arrangement, the upper surface of the opposing member is a hydrophilic surface and at least the peripheral portion region of the substrate-opposing surface is a hydrophobic surface. The processing liquid flowing down from the opposing member thereby flows down along the upper surface of the opposing member in a satisfactory manner without spilling over from the upper surface of the opposing member, then flows vertically downward from the end edge of the substrate-opposing surface of the opposing member without falling down by coming around to the substrate-opposing surface of the opposing member, and is supplied to the peripheral portion of the upper surface of the substrate at a fixed position. This eliminates variance in width of a region to be processed with the use of the processing liquid on the upper surface of the substrate, and a width of the region to be processed can be controlled accurately compared with a conventional apparatus.

Also, because the central portion (for example, a device-forming region) of the substrate, which is a region not to be processed, is protected by the opposing member, it is possible to prevent the central portion of the upper surface of the substrate from undergoing unwanted processing.

The opposing member may be formed in a shape of a rotational body having an axis line nearly along the rotational axis line as a central axis line.

A third aspect of the substrate processing apparatus of the invention is a substrate processing apparatus that applies processing, with the use of processing liquid, to a region to be processed including at least part of a peripheral portion of a substrate. The substrate processing apparatus includes: a substrate holding mechanism that holds the substrate; an opposing member that includes a substrate-opposing surface opposing an upper surface of the substrate held by the substrate holding mechanism and having an end edge corresponding to a boundary set on the upper surface of the substrate to divide the region to be processed and a region not to be processed as well as having a hydrophobic property at least in a peripheral portion region, and an hydrophilic upper surface inclined to near the end edge of the substrate-opposing surface as heading downward, the opposing member protecting the region not to be processed on the upper surface of the substrate by bringing the substrate-opposing surface in close proximity to the upper surface of the substrate; and a processing liquid supplying mechanism that supplies the processing liquid to the upper surface of the opposing member.

According to this arrangement, the upper surface of the opposing member is a hydrophilic surface and at least the peripheral portion region of the substrate-opposing surface is a hydrophobic surface. The processing liquid flowing down from the opposing member thereby flows down along the upper

surface of the opposing member in a satisfactory manner without spilling over outwards from the upper surface of the opposing member, then flows vertically downward from the end edge of the substrate-opposing surface of the opposing member without falling down by coming around to the substrate-opposing surface of the opposing member, and is supplied to the region to be processed on the upper surface of the substrate. It is thus possible to apply processing with the use of the processing liquid to a region to be processed of an arbitrary shape. Moreover, this eliminates the possibility of variance in width or shape of the region to be processed.

Also, because the region not to be processed on the upper surface of the substrate is protected by the opposing member, there is no possibility that the region not to be processed on the upper surface of the substrate undergoes unwanted processing.

Further, by rotating the substrate about an axis that intersects at right angles with the substrate by the substrate holding mechanism, the region to be processed can be an annular region in the peripheral portion of the substrate.

Also, the opposing member may further include a hydrophilic side surface that connects the end edge of the substrate-opposing surface and an end edge of the upper surface of the opposing member. In this case, the side surface is preferably a plane extending in a vertical direction, because

such a side surface can confer a vertically downward velocity vector to the processing liquid flowing down on the side surface toward the end edge of the substrate-opposing surface. This in turn makes it possible to guide and supply the processing liquid to the fixed position (on the boundary) on the upper surface of the substrate with good accuracy.

Also, it is preferable that the substrate processing apparatus further includes an inert gas supplying mechanism that supplies an inert gas to a space between the upper surface of the substrate held by the substrate holding mechanism and the substrate-opposing surface. By supplying an inert gas to a space between the upper surface of the substrate and the substrate-opposing surface of the opposing member, it is possible to prevent the central portion or a region not to be processed on the upper surface of the substrate from undergoing unwanted processing in a more reliable manner.

A third aspect of the substrate processing method of the invention is a method of applying processing to a peripheral portion of a substrate with the use of processing liquid. The method includes: a substrate rotating and holding step of rotating the substrate about a nearly vertical rotational axis line in an almost horizontal posture by a substrate holding mechanism; an opposing member approximating step of bringing an opposing member, provided with a substrate-opposing surface opposing an upper surface of the substrate held by the substrate

holding mechanism and having a hydrophobic property at least in a peripheral portion region and a hydrophilic upper surface inclined to near an end edge of the substrate-opposing surface as heading downward, in close proximity to the upper surface of the substrate held by the substrate holding mechanism; and a processing liquid supplying step of supplying the processing liquid to the upper surface of the opposing member in allowing the processing liquid to flow down to the peripheral portion of the substrate held by the substrate holding mechanism from the end edge of the substrate-opposing surface.

A fourth aspect of the substrate processing method of the invention includes: a substrate holding step of having a substrate holding mechanism hold the substrate almost horizontally; an opposing member approximating step of bringing an opposing member, provided with a substrate-opposing surface opposing an upper surface of the substrate held by the substrate holding mechanism and having an end edge corresponding to a boundary set on the upper surface of the substrate to divide the region to be processed and a region not to be processed as well as having a hydrophobic property at least in a peripheral portion region and a hydrophilic upper surface inclined to near the end edge of the substrate-opposing surface as heading downward, in close proximity to the upper surface of the substrate held by the substrate holding mechanism; and a processing liquid supplying

step of supplying the processing liquid to the upper surface of the opposing member in allowing the processing liquid to flow down to the region to be processed of the substrate held by the substrate holding mechanism from the end edge of the substrate-opposing surface.

A fourth aspect of the substrate processing apparatus of the invention is a substrate processing apparatus that applies processing to a peripheral portion of a substrate with the use of processing liquid. The substrate processing apparatus includes: a substrate holding mechanism that holds the substrate almost horizontally and rotates the substrate about a nearly vertical rotational axis line; an opposing member placed oppositely to an upper surface of the substrate held by the substrate holding mechanism and including a projection strip protruding toward the substrate at an edge portion; and a processing liquid supplying mechanism that supplies the opposing member with the processing liquid.

The opposing member may include a substrate-opposing surface having the projection strip protruding toward the substrate at an edge portion, and an upper surface connected to the projection strip. In this case, the processing liquid supplying mechanism may supply the processing liquid to the upper surface of the opposing member. The projection strip may be provided to part of the edge portion of the substrate-opposing surface of the opposing member, or it may

be a ring-shaped projection portion provided to the peripheral portion of the substrate-opposing surface of the opposing member along the entire circumference (across the entire region).

According to the above arrangement, the processing liquid supplied to the upper surface of the opposing member flows on the upper surface. Then, because the upper surface of the opposing member is connected to the projection strip, part of the processing liquid flowing on the upper surface comes around the upper surface to the projection strip, and flows downward to the peripheral portion of the upper surface of the substrate from the projection strip. It is thus possible to supply the processing liquid and thereby to apply processing with use of the processing liquid to the peripheral portion of the upper surface of the substrate regardless of whether the upper surface of the substrate is hydrophobic or hydrophilic.

It is preferable to connect the upper surface and the projection strip of the opposing member smoothly with a rounded plane having an arc-shaped convex-curved cross section. However, the upper surface and the projection strip of the opposing member are not necessarily connected to each other smoothly as long as the processing liquid supplied to the upper surface of the opposing member can come around to the projection strip. For example, the upper surface and the projection strip

of the opposing member may be connected directly, and a connecting portion may form a corner.

Also, because the substrate-opposing surface in the lower surface of the opposing member is located higher than the projection strip, the processing liquid coming around to the projection strip flows vertically downward from the projection strip without flowing to the substrate-opposing surface of the opposing member. The processing liquid is thus supplied to the upper surface of the substrate only at a region where the projection strip opposes, and the processing liquid is never supplied to a region inside the region where the projection strip opposes. Also, because the processing liquid is supplied to the upper surface of the substrate as flowing down from the projection strip, the supply position of the processing liquid on the upper surface of the substrate can remain at a fixed position. It is thus possible to control a width of the region to be processed on the upper surface of the substrate with accuracy.

Also, the projection strip of the opposing member may include a lower end edge located above the peripheral portion of the substrate held by the substrate holding mechanism. In this case, when the projection strip includes the lower end edge (where the projection strip includes a lower surface opposing the substrate held by the substrate holding mechanism, the lower end edge may be the lower surface), the processing

liquid coming around the upper surface of the opposing member to the projection strip is supplied to a gap between the lower end edge of the projection strip and the peripheral portion of the upper surface of the substrate. It is thus possible to control a width of a region to be processed with the use of the processing liquid on the upper surface of the substrate, by controlling the position of the lower end edge of the projection strip.

It is preferable that the upper surface of the opposing member is inclined to near a periphery of the substrate held by the substrate holding mechanism as heading downward. By inclining the upper surface of the opposing member, the processing liquid supplied to the upper surface of the opposing member can be introduced to the projection strip in a satisfactory manner. Further, when the upper surface of the opposing member includes a hydrophilic property, the processing liquid supplied to the upper surface of the opposing member can be introduced to the projection strip in a more satisfactory manner.

The projection strip of the opposing member may include, in a lower surface, a plane nearly parallel to the upper surface of the substrate held by the substrate holding mechanism. However, it is preferable that the projection strip of the opposing member includes, in a lower surface, an inclined plane that nears the upper surface of the substrate held by the

substrate holding mechanism as approaching the rotational axis line. The inclined plane may be a plane having a cross section linearly inclined to near the upper surface of the substrate held by the substrate holding mechanism as it approaches the rotational axis line, or a plane having a cross section convex-curved or concave-curved to near the upper surface of the substrate held by the substrate holding mechanism as it approaches the rotational axis line. When the projection strip includes an inclined plane in the lower surface, a large quantity of the processing liquid is allowed to come around to the lower surface of the projection strip, which in turn makes it possible to supply a large quantity of the processing liquid to the upper surface of the substrate at a region where the projection strip opposes.

Also, it is preferable that the projection strip of the opposing member includes, in a lower surface, a hydrophilic surface opposing the upper surface of the substrate held by the substrate holding mechanism. This also allows a large quantity of the processing liquid to come around to the lower surface of the projection strip, which in turn makes it possible to supply a large quantity of the processing liquid to the upper surface of the substrate at a region where the projection strip opposes.

The substrate processing apparatus may further include an opposing member rotating mechanism that rotates the

opposing member about the rotational axis line. According to this arrangement, for example, by rotating the opposing member when the processing liquid is supplied to the opposing member, it is possible to introduce the processing liquid supplied to the upper surface of the opposing member to the projection strip by a centrifugal force. Also, when the processing to the substrate ends, the opposing member can be dried by rotating the opposing member at a high speed in throwing off the processing liquid adhering to the opposing member.

When the opposing member is rotated while the processing liquid is supplied to the opposing member, it is preferable that the opposing member rotating mechanism rotates the opposing member at a rotational speed lower than a rotational speed at which the substrate is rotated by the substrate holding mechanism. By so doing, it is possible to prevent spilling over of the processing liquid from the opposing member that would occur otherwise by a centrifugal force induced by rotations of the opposing member and that would hence make it difficult for the processing liquid to come around to the peripheral portion of the upper surface of the substrate.

A fifth aspect of the substrate processing method of the invention is a method of applying processing to a peripheral portion of a substrate with the use of processing liquid. The method includes: a substrate rotating step of having a substrate holding mechanism hold the substrate almost

horizontally and rotating the substrate about a nearly vertical rotational axis line; an opposing member approximating step of bringing an opposing member, placed oppositely to an upper surface of the substrate held by the substrate holding mechanism and including a projection strip protruding toward the substrate at an edge portion, in close proximity to the substrate held by the substrate holding mechanism; and a processing liquid supplying step of supplying the processing liquid to the opposing member in allowing the processing liquid to flow down to the peripheral portion of the substrate held by the substrate holding mechanism from the projection strip.

The opposing member may include a substrate-opposing surface having the projection strip at an edge portion and an upper surface connected to the convex strip. In this case, the processing liquid supplying step may include a step of supplying the processing liquid to the upper surface of the opposing member.

The above and other objects, features, and advantages of the invention will become more apparent from the following description of embodiments with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross sectional view used to explain an

arrangement of a substrate periphery processing apparatus according to a first embodiment of the invention;

Fig. 2 is an enlarged cross sectional view used to explain an arrangement in close proximity to an annular member that controls a liquid film of etching liquid on a peripheral portion of the surface of a wafer;

Fig. 3 is a cross sectional view used to explain an arrangement of a substrate periphery processing apparatus according to a second embodiment of the invention;

Fig. 4 is a cross sectional view used to explain an arrangement of a substrate periphery processing apparatus according to a third embodiment of the invention;

Fig. 5(a) through Fig. 5(g) are partially enlarged cross sectional views used to explain various configurations of an annular member;

Fig. 6(a) through Fig. 6(c) are cross sectional views showing modifications as to the shape of an inner wall surface of the annular member;

Fig. 7(a) through Fig. 7(c) are cross sectional views showing modifications as to the shape of a wafer-opposing surface of the annular member;

Fig. 8(a) through Fig. 8(e) are cross sectional views showing modifications of a guide edge portion provided to the wafer opposing surface of the annular member;

Fig. 9(a) through Fig. 9(h) are schematic cross sectional

views showing examples of a configuration to supply the etching liquid to the peripheral portion of the upper surface of the wafer;

Fig. 10 is a view schematically showing an arrangement of a substrate periphery processing apparatus according to a fourth embodiment of the invention;

Fig. 11 is a cross sectional view showing a way in which the etching liquid flows down;

Fig. 12 is a plan view used to explain a fifth embodiment of the invention;

Fig. 13 is a plan view used to explain a sixth embodiment of the invention;

Fig. 14 is a view schematically showing an arrangement of a substrate processing apparatus according to a seventh embodiment;

Fig. 15 is a schematic cross sectional view showing a way in which etching processing is performed;

Fig. 16 is a schematic cross sectional view used to explain another arrangement (first modification) of an opposing member;

Fig. 17 is a schematic cross sectional view used to explain a further arrangement (second modification) of the opposing member;

Fig. 18 is a schematic cross sectional view used to explain still another arrangement (third modification) of the

opposing member; and

Fig. 19 is a plan view used to explain still another arrangement (fourth modification) of the opposing member.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a cross sectional view used to explain an arrangement of a substrate periphery processing apparatus according to one embodiment of the invention. The substrate periphery processing apparatus has the ability to remove a thin film formed on the peripheral portion of the surface (the upper surface, herein) and the end surface of a semiconductor wafer (hereinafter, referred to simply as the wafer) W, which is a substrate of a nearly circular shape. The substrate periphery processing apparatus includes, inside a processing cup (not shown), a spin chuck 1 that holds the wafer W almost horizontally with its back surface facing downward, and rotates about the vertical axis line passing the center or nearly the center of the wafer W thus held.

The spin chuck 1 is arranged in such a manner that it is rotated as being coupled to a rotating shaft 3, which is a driving shaft of a rotational driving mechanism 2 including a motor or the like. The rotating shaft 3 is a hollow shaft, into which is inserted a processing liquid supply pipe 4 where deionized water or etching liquid is supplied. The top end of the processing liquid supply pipe 4 is coupled to a central

axis nozzle (stationary nozzle) 5 having a dispense port 5a at a position in close proximity to the center of the lower surface of the wafer W held by the spin chuck 1. Deionized water or the etching liquid is supplied toward the center of the lower surface of the wafer W through the dispense port 5a of the central axis nozzle 5.

Deionized water or the etching liquid is supplied to the processing liquid supply pipe 4 at necessary timing via a deionized water supply valve 6 connected to a deionized water supply source or via an etching liquid supply valve 7 connected to an etching liquid supply source.

Used as the etching liquid is of a kind that corresponds to the kind of a thin film to be removed from the surface of the peripheral portion of the wafer W. More specifically, when a metal film, such as a copper thin film, is to be removed from the surface of the peripheral portion of the wafer W, for example, a liquid mixture of hydrochloric acid and hydrogen peroxide solution, a liquid mixture of hydrofluoric acid and hydrogen peroxide solution, or nitric acid is used as the etching liquid. When a polysilicon film, an amorphous silicon film or a silicon dioxide film is to be removed from the wafer W, for example, a liquid mixture of hydrofluoric acid and nitric acid is used as the etching liquid. Further, when an oxide film or a nitride film on the wafer W is to be removed, for example, hydrofluoric acids, such as DHF (dilute hydrofluoric

acid) and 50% hydrofluoric acid, are used as the etching liquid.

A space between the processing liquid supply pipe 4 and the rotating shaft 3 is used as a process gas supply path 8, which communicates with a space below the wafer W in the surrounding of the central axis nozzle 5. A process gas (for example, an inert gas, such as a nitrogen gas) is supplied from a process gas supply source to the process gas supply path 8 via a process gas supply valve 9.

A disc-shaped blocking plate 10 is placed horizontally above the spin chuck 1 to oppose the wafer W held by the spin chuck 1. The blocking plate 10 is of a size large enough to cover the upper surface of the wafer W almost entirely, and is allowed to move upward/downward with respect to the spin chuck 1 by a blocking plate elevator driving mechanism 11. The blocking plate 10 is also rotated coaxially about the rotational axis line of the spin chuck 1 by a motor 12 serving as a blocking plate rotational driving mechanism.

The motor 12 comprises a hollow motor in this embodiment, and the blocking plate 10 is coupled to the lower end of a rotating shaft 13 driven to rotate by the motor 12.

The rotating shaft 13 includes a hollow shaft, and a central axis nozzle 14 is inserted therein. Deionized water from the deionized water supply source is supplied to the central axis nozzle 14 via a deionized water supply valve 15, and chemical liquid (such as the etching liquid) from a chemical

liquid supply source is also supplied to the rotational axis nozzle 14 via a chemical liquid supply valve 16. The lower end of the central axis nozzle 14 fits in a through-hole 17 made in the blocking plate 10 at the center, and faces the center (rotational center) of the upper surface of the wafer W held by the spin chuck 1.

A gap between the rotating shaft 13 as a hollow shaft and the central axis nozzle 14 defines a process gas supply path 18, and the process gas supply path 18 faces the vicinity of the center of the upper surface of the wafer W through the through-hole 17 in the blocking plate 10. A process gas (an inert gas, such as a nitrogen gas) from the process gas supply source is supplied to the process gas supply path 18 via a process gas supply valve 19.

Inside a housing 20 accommodating the motor 12 are provided a bearing 21 that axially supports the rotating shaft 13, and a process gas supplying mechanism 22 that supplies an internal space of the blocking plate 10 with a process gas. The process gas supplying mechanism 22 includes a tubular labyrinth member 23 having a labyrinth surface that opposes the outer peripheral surface of the rotating shaft 13 as an inner peripheral surface, and a process gas introduction port 24 coupled to a process gas supply port 23a made in the labyrinth member 23.

The labyrinth member 23 is provided with an annular

groove 23b in the labyrinth surface at a position corresponding to the process gas supply port 23a. A seal gas supplied through a seal gas introduction port 25 is supplied to labyrinth portions above and below the annular groove 23b.

A process gas (an inert gas, such as a nitrogen gas) is supplied from the process gas supply source to the process gas introduction port 24 via a process gas supply valve 26, and a seal gas (dry air or the like) is supplied from a seal gas supply source to the seal gas introduction port 25 via a seal gas supply valve 27.

An internal atmosphere in the vicinity of the lower end of the labyrinth member 23 is taken in and exhausted through an intake port 28, so that the process gas or the seal gas will not leak into the processing chamber.

The rotating shaft 13 is of a double-axis structure comprising an inside axis 13A and an outside axis 13B surrounding the inside axis 13A, and the lower end of the outside axis 13B is supported by an outward flange 29 formed in the vicinity of the lower end of the inside axis 13A. The outside axis 13B opens at a position opposing the annular groove 23b of the labyrinth member 23, and a process gas path 30 is formed within the thickness to extend in the axial direction. The process gas path 30 penetrates through a through-hole made in the flange 29 and a through-hole made in a top lid portion 31 of the blocking plate 10, and communicates with the internal

space of the blocking plate 10.

The process gas supplied through the process gas introduction port 24 is introduced into the process gas path 30 in the rotating shaft 13 while being sealed by a seal gas on the labyrinth surface of the labyrinth member 23.

The blocking plate 10 is provided with the circular-disc-shaped top lid portion 31, a cylindrical annular member 32 coupled to the lower surface of the top lid portion 31 at the peripheral portion, and a circular-disc-shaped center plate 33 coupled to the top lid portion 31 from below. The top lid portion 31, the annular member 32, and the center plate 33 together define a gas space 34 inside the blocking plate 10. A process gas from the process gas path 30 is introduced into the gas space 34.

A fine slit is formed between the center plate 33 and the inner wall surface of the annular member 32 along the entire circumference. The slit forms a gas nozzle 35 through which the process gas is discharged toward the inner periphery of the lower end of the annular member 32.

Fig. 2 shows an enlarged cross section in close proximity to the annular member 32. The wafer W subject to processing is clamped by a plurality of (for example, three) chuck pins 41 provided to the spin chuck 1. Each chuck pin 41 is provided with a supporting portion 42 that supports the peripheral portion of the lower surface of the wafer W, and a guide pin

43 that abuts on the end surface of the wafer W and thereby regulates a horizontal movement of the wafer W.

The annular member 32 is located inside the guide pin 43 in the direction of turning radius of the wafer W, and opposes the peripheral portion of the upper surface of the wafer W above the wafer W held by the spin chuck 1. To be more concrete, the annular member 32 includes a wafer-opposing surface 45 that opposes the surface of the peripheral portion of the upper surface of the wafer W, a guide edge portion 46 protruding toward the surface of the wafer W at the inner periphery of the wafer-opposing surface 45, an inner wall surface 47 rising vertically upward (in a direction to move away from the surface of the wafer W) from the inner periphery of the guide edge portion 46, and an outer wall surface 48 rising vertically upward from the outer periphery of the wafer-opposing surface 45. The guide edge portion 46 is formed at the lower end of the inner wall surface 47 of the annular member 32 along the entire circumference, and thereby forms an annular convex strip.

A liquid film 50 of the etching liquid is formed in a gap between the wafer-opposing surface 45 and the peripheral portion of the wafer W. The liquid film 50 comes in contact with the wafer-opposing surface 45 and its movement toward the inside of the wafer W is limited by the guide edge portion 46.

Meanwhile, the center plate 33 includes, at the outer

periphery of the lower surface, which is the surface opposing the wafer W, an annular groove (counter-bore portion) 51 that opens outwards in the direction of radius, and a chamfered-corner portion 52 in the peripheral portion on the upper surface side that does not oppose the wafer W. The chamfered-corner portion 52 narrows a path of the process gas supplied to the gas nozzle 35 from the gas space 34, and thereby allows the gas nozzle 35 to vigorously blow out the process gas vertically downward to the upper surface of the wafer W along the inner wall surface 47 of the annular member 32. In other words, the process gas changes its direction to head downward to the wafer W due to the presence of the inner wall surface 47 of the annular member 32, and is blown out from the gas nozzle 35 toward the upper surface of the wafer W along the inner wall surface 47.

Degassing paths 49 that open both in the inner wall surface 47 and the outer wall surface 48 and thereby allow a communication between an internal space of the annular groove 51 and an external space of the blocking plate 10 are formed in the annular member 32 at positions opposing the annular groove 51. The degassing paths 49 comprise circular holes of a fine diameter (for example, 0.5 mm in diameter), and a plurality of them are formed at equiangular intervals (for example, 72 of them at 5° intervals) in the circumferential direction of the annular member 32. Even when the liquid film

50 of the etching liquid is formed between the wafer-opposing surface 45 and the surface of the peripheral portion of the wafer W, the degassing paths 49 serve to eliminate a pressure difference between a space 40 present between the blocking plate 10 and the upper surface of the wafer W and the external space of the blocking plate 10.

On the other hand, the guide edge portion 46 formed at the inner periphery of the wafer-opposing surface 45 includes an etching liquid limiting surface 46a on the outer side in the direction of the turning radius of the wafer W. The etching liquid limiting surface 46a forms an inclined plane (inverted conical plane) heading outwards as it moves away from the wafer W. The etching liquid limiting surface 46a conforms to the shape of the liquid film 50 of the etching liquid, and thereby prevents the liquid film 50 from entering the central region of the wafer W in a reliable manner.

It is preferable that the inner wall surface 47 of the annular member 32 is provided slightly outside (for example, 0.1 to a few mm outside, the range, however, varies depending on the kinds of the etching liquid and the surface conditions of the wafer W) the inner periphery of the region subject to processing in the peripheral portion of the upper surface of the wafer W (a region 3 to 5 mm inside the outer peripheral end of the wafer W). In other words, it is preferable that the inner periphery of the annular member 32 forms a circle

having a diameter shorter than the diameter of the wafer W, but slightly larger than the diameter of the circle shaped by the inner periphery of the region subject to processing in the peripheral portion of the upper surface of the wafer W.

Although it depends on the kinds of the etching liquid and the surface conditions of the wafer W, it is preferable to set the interval between the wafer-opposing surface 45 and the surface of the peripheral portion of the wafer W to 0.3 to 5 mm approximately.

Likewise, it is preferable to set the interval between the lower end (the portion in the closest proximity to the wafer W) of the guide edge portion 46 and the surface of the wafer W to, for example, 0.1 to 3 mm approximately, although the range varies with the kinds of the etching liquid and the surface conditions of the wafer W.

The annular groove 51 formed adjacently inside the inner wall surface 47 of the annular member 32 is a groove recessed in a direction to move away from the surface of the wafer W, and it is preferable to set the width of the groove to 1 mm or greater.

As shown in Fig. 1, the spin chuck 1 is provided with a disc-shaped spin base 441 and a spin chuck driving mechanism 44 that activates the chuck pins 41 provided to stand on the spin base 441. The chuck pin driving mechanism 44 includes, for example, a linking mechanism 442 provided in the interior

of the spin base 441 and a driving mechanism 443 that drives the linking mechanism 442. The driving mechanism 443 is provided with a rotary-side driving force delivery member 444 that rotates together with the rotating shaft 3, a stationary-side driving force delivery member 446 coupled to the outer periphery of the rotary-side driving force delivery member 444 through a bearing 445, and a chuck-pin-drive elevator driving mechanism 447 that moves the stationary-side driving force delivery member 446 upward/downward.

When the stationary-side driving force delivery member 446 is moved upward/downward by the chuck-pin-drive elevator driving mechanism 447, the rotary-side driving force delivery member 444 starts to move upward/downward in association, and this elevator motion is transferred to the linking mechanism 442 to be converted into an operation of the chuck pins 41. Hence, by activating the chuck-pin-drive elevator driving mechanism 447, it is possible to clamp the wafer W by the chuck pins 41 or release the clamping. Because the stationary-side driving force delivery member 446 and the rotary-side driving force delivery member 444 are coupled to each other through the bearing 445, the clamping position of the wafer W can be changed even when the spin chuck 1 is rotating, by releasing or relaxing the clamping of the wafer W by the chuck pins 41.

When the wafer W subject to processing is introduced to the spin chuck 1, the blocking plate 10 is retracted to an

evacuation position away above the spin chuck 1 by the operation of the blocking plate elevator driving mechanism 11. Under these conditions, the unprocessed wafer W is delivered to the spin chuck 1 by an unillustrated substrate-transporting robot. Subsequently, the wafer W is clamped by the chuck pins 41 by the operation of the chuck pin driving mechanism 44.

Then, the blocking plate 10 is lowered toward the spin chuck 1 by the operation of the blocking plate elevator driving mechanism 11 until the center plate 33 is located in close proximity to the central region of the wafer W while the annular member 32 is in close proximity to the surface of the peripheral portion of the wafer W. In this instance, for example, 0.5 mm is given as the interval between the upper surface of the wafer W and the wafer-opposing surface 45. The spin chuck 1 is driven to rotate by the rotational driving mechanism 2, and the blocking plate 10 is driven to rotate by the motor 12 under these conditions. In this instance, the rotational driving mechanism 2 and the motor 12 are controlled so that the spin chuck 1 and the blocking plate 10 rotate synchronously, that is, rotate in the same direction at substantially the same rotational speed.

When the etching liquid supply valve 7 is opened under these conditions, the etching liquid is supplied toward the center on the back surface of the wafer W from the central axis nozzle 5. The etching liquid is forced to flow on the lower

surface of the wafer W by a centrifugal force to the peripheral end surface, and reaches the peripheral portion of the upper surface of the wafer W by coming around the peripheral end surface.

As shown in Fig. 2, the liquid film 50 is formed in a gap between the wafer-opposing surface 45 of the annular member 32 and the surface of the peripheral portion of the wafer W. The liquid film 50 comes in contact with the wafer-opposing surface 45 and further comes in contact with the etching liquid limiting surface 46a of the guide edge portion 46. Because the inner side of the guide edge portion 46 continues with the inner wall surface 47 that stands upright or nearly upright with respect to the surface of the wafer W, the liquid film 50 of the etching liquid cannot enter an inner region of the wafer W far from the inner wall surface 47 of the annular member 32. This makes it possible to control the etching width in the peripheral portion of the upper surface of the wafer W with high accuracy.

Meanwhile, either or both of the process gas supply valve 19 and the process gas supply valve 26 are opened, and the process gas is supplied to the annular groove 51 from the gas space 34 and the space 40 above the upper surface of the wafer W. Pressure applied by the process gas can prevent the liquid film 50 of the etching liquid from entering an inner region of the wafer W in a reliable manner. The liquid film 50 seals

an internal space of the annular member 32 hermetically. However, because the internal space of the annular groove 51 and the external space of the blocking plate 10 communicate with each other through the degassing paths 49, breaking caused by a pressure difference between the inside and the outside of the blocking plate 10 will not occur anywhere in the liquid film 50.

When the etching processing is performed on the surface of the peripheral portion of the wafer W for a predetermined time under these conditions, the etching liquid supply valve 7 is closed, and the blocking plate 10 is moved upward to a predetermined height (for example, to a position at which 50 mm is given as the interval between the wafer-opposing surface 45 and the upper surface of the wafer W) by the blocking plate elevator driving mechanism 11. Subsequently, the deionized water supply valve 6 is opened, the process gas supply valve 26 is closed, and the deionized water supply valve 15 is opened. Deionized water is thereby supplied to the upper and lower surfaces of the wafer W to perform deionized water rinsing processing that rinses the wafer W with water.

Then, the deionized water supply valves 6 and 15 are closed, and the blocking plate 10 is lowered again by the blocking plate elevator driving mechanism 11 to come in close proximity to the upper surface of the wafer W (for example, to a position at which 0.3 mm is given as the interval between

the wafer-opposing surface 45 and the upper surface of the wafer W). The spin chuck 1 is driven to rotate at a high speed under these conditions to perform drying processing that removes water on the wafer W by throwing off the water with a centrifugal force.

The process gas supply valves 9 and 19 remain open during the processing of the wafer W and thereby maintain the upper and lower surfaces of the wafer W in an inert gas atmosphere. Likewise, the seal gas supply valve 27 remains open during the processing of the wafer W, and thereby prevents an atmosphere from flowing in and out from a path of the process gas.

As has been described, according to this embodiment, the liquid film 50 of the etching liquid in the peripheral portion of the wafer W is limited by the annular member 32 in a reliable manner so as not to enter an inner region of the wafer W. This makes it possible to control the etching width in the peripheral portion of the wafer W with high accuracy as well as to apply the processing to the peripheral portion of the wafer W in a satisfactory manner.

Fig. 3 shows a cross section of a substrate periphery processing apparatus according to a second embodiment of the invention. In Fig. 3, components corresponding to those shown in Fig. 1 are labeled with like reference numerals with respect to Fig. 1.

In this embodiment, the spin base 441 of the spin chuck

1 is provided with a plurality of receive pins 61 used to receive and hold a blocking plate 60 at intervals in the circumferential direction (for example, three of them at equiangular intervals). The blocking plate 60 comprises a plate-shaped body having a major diameter larger than the diameter of the wafer W, and is provided with a plurality of through-holes 62 made in the peripheral portion in the circumferential direction at intervals so as to engage with the receive pins 61. The blocking plate 60 is held above the spin base 441 as the lower surface is supported by shoulder portions 61a of the receive pins 61 at the peripheral portions of the through-holes 62, and is thereby driven to rotate together with the spin base 441. The blocking plate 60, being held by the receive pins 61, is located so that its lower surface 63 is in close proximity to the upper surface of the wafer W held by the spin chuck 1.

The blocking plate 60 includes a through-hole 64 at the center, and includes an annular portion 65 integrally at a position corresponding to the peripheral portion of the upper surface of the wafer W. At an adjacent position inside the annular portion 65, an annular groove 66 recessed in a direction to move away from the wafer W is provided along the entire circumference. The portions of the blocking plate 60 other than the annular portion 65 together form a lid portion that substantially clogs a space surrounded by the annular portion 65.

The annular portion 65 includes a wafer-opposing surface 67 that opposes the peripheral portion of the wafer W, a guide edge portion 68 that protrudes to come in close proximity to the upper surface of the wafer W at the inner periphery of the wafer-opposing surface 67, an inner wall surface 69 that rises from the guide edge portion 68 vertically upward in a direction to move away from the wafer W, and an outer wall surface 70 that rises from the periphery of the wafer-opposing surface 67 on the outer side in the direction of the turning radius. The inner periphery of the wafer-opposing surface 67 is of a circular shape having a diameter smaller than the diameter of the wafer W. The circle shaped by the inner periphery is slightly larger than the inner periphery of the region subject to processing in the peripheral portion of the upper surface of the wafer W.

A flange pipe 71 including an internal space that communicates with a through-hole 64 is coupled to the upper surface of the blocking plate 60. Further, a blocking plate flange 72 including a through-hole at the center is coupled to the top end of the flange pipe 71. A central axis nozzle 75 is provided to penetrate through the through-hole at the center of the blocking plate flange 72 and the internal space of the flange pipe 71 to reach the through-hole 64.

The central axis nozzle 75 comprises a double-pipe including a processing liquid supply pipe 76 and a process gas

supply pipe 77, and therefore has the ability to supply processing liquid (deionized water or chemical liquid) to the upper surface of the wafer W from the processing liquid supply pipe 76 as well as to supply the process gas to a space between the upper surface of the wafer W and the blocking plate 60 from a space between the processing liquid supply pipe 76 and the process gas supply pipe 77. The process gas heads outwards in the direction of the radius of the wafer W by flowing on the upper surface thereof, then collides with the inner wall surface 69 of the annular portion 65, and moves downward to the upper surface of the wafer W along the inner wall surface 69.

As with the first embodiment described above, the annular portion 65 is provided with a number of degassing paths 80 made in the circumferential direction at intervals to allow a communication between the inner wall surface 69 and the outer wall surface 70.

A blocking-plate-side labyrinth member 73 is fixed onto the upper surface of the blocking plate flange 72, and a nozzle-side labyrinth member 74 is coupled to the blocking-plate-side labyrinth member 73 in a non-contact state. A seal gas (purge gas) is supplied to a space between the blocking-plate-side labyrinth member 73 and the nozzle-side labyrinth member 74.

The nozzle-side labyrinth member 74 is fixed to a nozzle

holding portion 78 held in a non-rotational state. The nozzle holding portion 78 is moved upward/downward by a nozzle elevator driving mechanism 79.

On the other hand, in order to move the blocking plate 60 upward/downward, a blocking plate hand 81 and a blocking plate elevator driving mechanism 82 that moves the blocking plate hand 81 upward/downward are provided. The blocking plate hand 81 is provided with a through-hole for the flange pipe 71 to penetrate through, and a plurality of hand pins 83 that engage with a plurality of through-holes 72a made in the peripheral portion of the blocking plate flange 72, respectively.

According to this arrangement, by moving the blocking plate hand 81 upward/downward by the blocking plate elevator driving mechanism 82, the blocking plate 60 is allowed to retract above the spin chuck 1 or to engage with the receive pins 61 provided to the spin chuck 1.

According to this substrate periphery processing apparatus, the blocking plate 60 receives a rotational force from the spin chuck 1 and thereby rotates together with the spin chuck 1. It should be appreciated, however, that the processing to be applied to the peripheral portion of the upper surface of the wafer W is substantially the same as in the first embodiment described above.

In other words, the etching liquid supplied from the

central axis nozzle 5 toward the center of the lower surface of the wafer W is forced outwards in the direction of the radius by a centrifugal force, and reaches the peripheral portion of the upper surface of the wafer W by coming around the peripheral end surface. The etching liquid then forms a liquid film in a gap between the peripheral portion of the upper surface of the wafer W and the wafer-opposing surface 67 of the annular portion 65. The liquid film thus formed comes in contact with the wafer-opposing surface 67, and further comes in contact with the guide edge portion 68. The etching processing can thus take place in the peripheral portion of the upper surface of the wafer W while the etching processing width is controlled with accuracy.

On the other hand, the process gas supplied from the process gas supply pipe 77 to the space above the wafer W collides with the inner wall surface 69 of the annular groove 66 formed inside the annular portion 65, which gives rise to an airflow heading downward along the inner wall surface 69. It is thus possible to prevent the etching liquid from entering an inner region of the wafer W in a reliable manner.

Also, because the degassing paths 80 that allow a communication between the internal space of the annular groove 66 and the external space of the blocking plate 60 are formed in the annular portion 65, a large pressure difference will not be produced between the inside and the outside of the

annular portion 65. Therefore, there is no possibility that breaking occurs anywhere in the liquid film of the etching liquid formed on the peripheral portion of the upper surface of the wafer W.

Fig. 4 shows a cross section of a substrate periphery processing apparatus according to a third embodiment of the invention. In Fig. 4, components furnished with like functions as those shown in Fig. 1 are labeled with the like reference numerals with respect to Fig. 1.

In this embodiment, the top lid portion 31 of the blocking plate 10 is provided with a liquid-receiving groove 85 having a funnel-shaped cross section in the peripheral portion along the entire circumference above the annular member 32. Openings (discharge ports) are provided in the bottom portion of the liquid-receiving groove 85 in the circumferential direction at adequate intervals, and the openings communicate respectively with a plurality of processing liquid supply paths 86 made in the annular member 32 along the vertical direction. In short, a plurality of the processing liquid supply paths 86 are provided along the circumferential direction of the annular member 32, for example, at equiangular intervals (for example, 72 of them at 5° intervals).

Each processing liquid supply path 86 includes a dispense port that opens in the wafer-opposing surface 45 (for example, a circular hole having a diameter of 0.5 mm), and supplies the

etching liquid to a space between the wafer-opposing surface 45 and the peripheral portion of the upper surface of the wafer W in a direction perpendicular or perpendicular to the upper surface of the wafer W. A liquid film of the etching liquid that comes in contact with the wafer-opposing surface 45 is thereby formed in the peripheral portion of the upper surface of the wafer W.

The etching liquid is supplied to the liquid-receiving groove 85 continuously or intermittently from a movable nozzle 88 provided in a displaceable manner in a direction to come in close proximity to or move away from the rotational axis line of the blocking plate 10. It is arranged in such a manner that the etching liquid is supplied to the movable nozzle 88 from the etching liquid supply source via an etching liquid supply valve 89. It should be noted that, in this embodiment too, the etching liquid is supplied to the lower surface of the wafer W from the central axis nozzle 5 below the wafer W, and therefore the etching processing is applied to the lower surface of the wafer W.

According to the foregoing arrangement, the etching processing to the peripheral portion of the wafer W, the deionized water rinsing processing to the upper and lower surfaces of the wafer W, and the drying processing to the upper and lower surfaces of the wafer W can be performed in the same manner as the first embodiment described above.

It should be noted, however, that according to the arrangement of this embodiment, a supply of the etching liquid from the central axis nozzle 5 pointed to the lower side of the wafer W is not necessarily required in the step of applying the etching processing to the peripheral portion of the upper surface of the wafer W. In other words, in a case where the etching processing need not to be applied to the lower surface of the wafer W, a supply of the etching liquid from the central axis nozzle 5 can be omitted.

When a supply of the etching liquid from the central axis nozzle 5 is omitted, it is not necessary to transfer the etching liquid to the peripheral end surface of the wafer W by a centrifugal force, either. It is therefore sufficient to rotate the spin chuck 1 and the blocking plate 10 at a lower rotational speed than in the first embodiment.

Further, according to the arrangement of this embodiment, the etching processing can be applied to the peripheral portion of the wafer W while the spin chuck 1 is substantially held at rest.

In short, the blocking plate 10 is rotated at a low speed while the spin chuck 1 is stopped rotating. Under these conditions, the etching liquid is supplied along the entire circumference of the liquid-receiving groove 85 from the movable nozzle 88, then the etching liquid is supplied to the peripheral portion of the upper surface of the wafer W through

the processing liquid supply paths 86. A supply of the etching liquid is stopped by closing the valve 89 after a necessary quantity of the etching liquid is supplied, and the blocking plate 10 is stopped rotating. A mound of the etching liquid is thus placed on the surface of the peripheral portion along the entire circumference. By maintaining this liquid mounding state for a predetermined time (for example, five to forty seconds), selective etching processing can be applied to the peripheral portion of the wafer W. The liquid mounding processing as described above can reduce a quantity of consumed etching liquid markedly. A mound of the etching liquid placed in this manner forms a liquid film that comes in contact with the wafer-opposing surface 45 of the annular member 32. The guide edge portion 46 limits the movement of the liquid film toward the inside of the wafer W in a reliable manner.

Even in the case of the liquid mounding processing, the etching liquid may be supplied to the liquid-receiving groove 85 from the movable nozzle 88 continuously or intermittently. Also, the spin chuck 1 may be rotated at a speed low enough to prevent a mound of the etching liquid placed on the peripheral portion of the wafer W from being discharged to the outside of the wafer W by a centrifugal force.

In the above description, the etching liquid is supplied to the wafer W while the blocking plate 10 is rotated at a low speed whereas the spin chuck 1 is stopped rotating. However,

besides this arrangement, the etching liquid may be supplied to the wafer W while both the spin chuck 1 and the blocking plate 10 are rotated at different low speeds, or while the spin chuck 1 is rotated at a low speed whereas the blocking plate 10 is stopped rotating. Alternatively, the etching liquid may be supplied to the wafer W by moving the movable nozzle 88 along the entire circumference of the liquid-receiving groove 85 while both the spin chuck 1 and the blocking plate 10 are stopped rotating. In any case, a mound of the etching liquid can be placed on the peripheral portion of the upper surface of the wafer W along the entire circumference.

"The low speed" of the spin chuck 1 and the blocking plate 10 referred to herein means a rotational speed low enough to prevent the etching liquid on the peripheral portion of the upper surface of the wafer W from spilling outwards, and for example, a rotational speed at or below 60 rpm is preferable.

As has been described, by supplying the etching liquid to the peripheral portion of the upper surface of the wafer W while the wafer-opposing surface 45 of the annular member 32 is brought in close proximity to the peripheral portion of the upper surface of the wafer W, the etching liquid is maintained stably in a gap between the wafer-opposing surface 45 and the peripheral portion of the upper surface of the wafer W. It is thus possible to perform the etching processing in a satisfactory manner without consuming a large quantity of

the etching liquid.

It should be appreciated that after the peripheral portion of the upper surface of the wafer W is processed by placing a mound of the etching liquid thereon, the rinsing of the wafer W with water followed by the drying processing is performed in the same manner as was discussed in the first embodiment above.

Fig. 5(a) through Fig. 5(g) show partially enlarged cross sections used to explain various configurations of the annular member that controls a liquid film of the etching liquid at the peripheral portion of the surface of the wafer W. The example of Fig. 5(f) is the same as the arrangement of the first embodiment shown in Fig. 1 and Fig. 2. The example of Fig. 5(d) is the same as the arrangement of the second embodiment shown in Fig. 3. In the drawings, capital letter E indicates the etching liquid.

Fig. 5(a) shows the most basic configuration of the annular member, and it shows an annular member including the inner periphery with a diameter smaller than the diameter of the wafer W, and the wafer-opposing surface 45 opposing the peripheral portion of the upper surface of the wafer W. No guide edge portion is provided to the inner periphery of the wafer-opposing surface 45. However, even in the absence of the guide edge portion, a liquid film of the etching liquid E is limited at a position slightly inside the wall surface

47 of the annular member, and the liquid film is thereby controlled so as not to enter an inner region of the wafer W. Also, the wafer-opposing surface 45 comes in contact with the liquid film of the etching liquid E and produces a liquid sealing state.

The example of the arrangement shown in Fig. 5(b) is achieved by developing the arrangement of Fig. 5(a), in which a lid portion 90 is provided integrally. By providing the lid portion 90, it is possible to prevent droplets in the surroundings from passing through the annular member to be scattered in the central region (device-forming region) of the wafer W or mist from adhering to the central portion.

The arrangement shown in Fig. 5(c) is achieved by further developing the configuration of Fig 5(b), in which the annular groove 51 is provided adjacently inside the inner wall surface 47 of the annular member. The arrangement in the configuration shown in Fig. 5(d) is achieved by further developing the arrangement of Fig. 5(c), in which the guide edge portion 46 is provided so as to control the liquid film of the etching liquid E not to enter an inner region of the wafer W in a reliable manner.

The configuration shown in Fig. 5(e) is achieved by further developing the configuration of Fig. 5(d), in which a gas is supplied to the inner wall surface 47 of the annular member, so that the gas is blown out from the gas nozzle 35

to the surface of the wafer W along the inner wall surface 47. According to this arrangement, because the interior of the annular member can be maintained at a positive pressure, a liquid film of the etching liquid E can be controlled with high accuracy.

Further, the arrangement of Fig. 5(f) is achieved by modifying the arrangement of Fig. 5(e), in which a counter-bore portion is formed at the outer periphery of the lower surface of the central plate 33 to form the annular groove 51 between the center plate 33 and the inner wall surface 47 of the annular member. When the configuration of Fig. 5(e) is compared with the configuration of Fig. 5(f), because the annular groove is not provided at a position adjacently inside the inner wall surface 47 of the annular member in the configuration of Fig. 5(e), it can be the that the arrangement of Fig. 5(f) excels in the control ability as to a liquid film of the etching liquid E.

As shown in Fig. 5(g), the outer periphery of the wafer-opposing surface 45 of the annular member may be located outside the outer periphery of the wafer W. The wafer-opposing surface 45 may be formed to extend outwards beyond the outer periphery of the wafer W. By adopting such an arrangement, it is possible to trap the etching liquid E supplied from the lower surface of the wafer W in a satisfactory manner on the peripheral end surface of the wafer W. It is thus possible

to form a satisfactory liquid film on the peripheral portion of the upper surface of the wafer W in a reliable manner.

Fig. 6(a) through Fig. 6(c) are cross sections showing modifications as to the shape of the inner wall surface of the annular member. In the example shown in Fig. 6(a), the inner wall surface 47 forms an inclined plane (conical plane) heading toward the inside of the wafer W as it moves away from the upper surface of the wafer W.

In the example of Fig. 6(b), the inner wall surface 47 forms an inclined plane (inverted conical plane) heading toward the outside of the wafer W as it moves away from the upper surface of the wafer W.

According to the arrangement of Fig. 6(c), the inner wall surface 47 forms a bent plane including an upright rising surface 47a that rises upright or nearly upright from the upper surface of the wafer W, and an inclined plane 47b that continues from the upper edge of the upright rising surface 47a while heading toward the inside of the wafer W as it moves away from the upper surface of the wafer W.

By forming the inner wall surface 47 of the annular member as the inclined plane in the configuration of Fig. 6(a), the etching liquid E heading toward the inside of the wafer W tries to move away from the surface of the wafer W along the inclined inner wall surface 47. However, such a movement of the etching liquid E along the inner wall surface 47 is prevented by gravity.

When the annular member is rotating, in particular, the movement of the etching liquid E along the inner wall surface 47 is prevented by a centrifugal force. This prevents the etching liquid E from reaching an inner side of the wafer W in a reliable manner by controlling a liquid film of the etching liquid E to be formed under the wafer-opposing surface in a reliable manner.

Fig. 7(a) through Fig. 7(c) are cross sections showing modifications as to the shape of the wafer-opposing surface of the annular member. In the example of Fig. 7(a), the wafer-opposing surface 45 forms an inclined plane (inverted conical plane) that comes in close proximity to the upper surface of the wafer W as it heads toward the inside of the wafer W.

Also, in the example of Fig. 7(b), the wafer-opposing surface 45 forms a curved plane that curves so as to come in close proximity to the upper surface of the wafer W as it heads toward the inside of the wafer W.

Further, in the example of Fig. 7(c), the wafer-opposing surface 45 forms a bent plane including an outer-periphery-side parallel portion 45a that is provided on the outer periphery side and substantially parallel to the upper surface of the wafer W, an inner-periphery-side parallel portion 45c that is provided inside the outer-periphery-side parallel portion 45a and comes in closer proximity to the upper

surface of the wafer W than the outer-periphery-side parallel portion 45a while being parallel to the upper surface of the wafer W, and an inclined portion 45b that couples the inner-periphery-side parallel portion 45c to the outer-periphery-side parallel portion 45a. The inclined portion 45b forms an inclined plane (inverted conical plane) that comes in close proximity to the wafer W as it heads toward the inside of the wafer W.

In any of the arrangements of Fig. 7(a), Fig. 7(b), and Fig. 7(c), a distance between the wafer-opposing surface 45 and the upper surface of the wafer W becomes shorter in the inner side of the wafer W. By forming the wafer-opposing surface 45 in any of the shapes as above, a liquid film of the etching liquid E can be controlled in a more satisfactory manner, which makes it possible to prevent the etching liquid E from entering an inner region of the wafer W in a reliable manner. Because the etching liquid can be more readily introduced into a space between the wafer-opposing surface 45 and the upper surface of the wafer W, a liquid sealing state can be produced in a satisfactory manner.

Fig. 8(a) through Fig. 8(e) are cross sections showing modifications of the guide edge portion 46 provided to the wafer-opposing surface 45 of the annular member. The example of Fig. 8(a) is a case where the side surface of the guide edge portion 46 on the inner side of the wafer W is formed as an

inclined plane (conical plane) heading toward the inside of the wafer W as it moves away from the surface of the wafer W, while the side surface of the guide edge portion 46 on the outer side of the wafer W is formed as an inclined plane (inverted conical plane) heading toward the outside of the wafer W as it moves away from the surface of the wafer W.

The example of Fig. 8(b) is a case where a convex strip having a nearly rectangular cross section is provided as the cross section of the guide edge portion 46, and a cylindrical surface nearly perpendicular to the upper surface of the wafer W is provided as the etching liquid limiting surface 46a.

The example of Fig. 8(c) is a case where the etching liquid limiting surface 46a is formed not as an inclined plane (conical plane) but as a curved plane that forms a rounded plane in cross section.

Further, the example of Fig. 8(d) is a case where a wafer-opposing portion 46b that opposes the wafer W is provided to the lower end of the guide edge portion 46 by shifting the etching liquid limiting surface 46a toward the outside of the wafer W, and a liquid-releasing path 95 that opens in the wafer-opposing portion 46b is made in the annular member. The liquid-releasing path 95 opens also in the outer wall surface 48 of the annular member.

For example, when the annular member is rotated together with the blocking plate 10, a centrifugal force acts on the

etching liquid E inside the liquid-releasing path 95, and the etching liquid E is pumped up from the wafer-opposing portion 46b of the guide edge portion 46, passes through the liquid-releasing path 95, and is discharged to the outside of the annular member. It is thus possible to prevent the etching liquid E from entering inside the annular member in a more reliable manner.

In the example of Fig. 8(e), the liquid-releasing path 95 merges with the degassing paths 49. In other words, when the process gas is supplied to the inside of the annular member, the process gas is discharged to the outside of the annular member by passing through the degassing paths 49. In this instance, the ejector effect is induced, by which the etching liquid E is pumped up from the wafer-opposing portion 46b and discharged to the outside.

Fig. 9(a) through Fig. 9(h) are schematic cross sections showing examples of a configuration to supply the etching liquid E to the peripheral portion of the upper surface of the wafer W. Fig. 9(a) shows the example shown in Fig. 1 and Fig. 3. To be more specific, the etching liquid E is supplied toward the center of the lower surface of the wafer W, and the etching liquid E is guided toward the outside of the wafer W by a centrifugal force, and reaches the peripheral portion of the upper surface of the wafer W by coming around the peripheral end surface.

The example of Fig. 9(b) shows a case where the etching liquid E is provided toward the peripheral portion of the lower surface of the wafer W from a nozzle 100 provided below the wafer W (that is, below the spin chuck 1). In this case also, the etching liquid E receiving a centrifugal force on the lower surface of the wafer W comes around the peripheral end surface of the wafer W and reaches the peripheral portion of the upper surface. The example of Fig. 9(b) shows a case where the etching liquid E is discharged through the discharge port of the nozzle 100 at an inclined angle heading toward the outside of the wafer W (for example, 10 to 45 degrees, and preferably 30 degrees) from below the wafer W, and is incident on the lower surface of the wafer W at the same angle.

The example of Fig. 9(c) shows a case where the etching liquid E is supplied from above to the upper surface of the wafer W outside the annular member 32 from a nozzle 101 provided above the wafer W. In this case, it is preferable that the annular member 32 is arranged to have an outer wall surface 48 well inside the peripheral end surface of the wafer W. Even when arranged in this manner, it is still possible to prevent a liquid film of the etching liquid E from entering the central region of the wafer W by the annular member 32.

Although the nozzle 101 is provided just above the peripheral region of the wafer, such a nozzle may be located outside of the area just above the wafer to supply the etching

liquid E in the inclined direction with respect to the surface of the wafer W.

The example of Fig. 9(d) is a case where the etching liquid E is supplied from a nozzle 102 toward the outer wall surface 48 of the annular member 32. In this case, the etching liquid E thus supplied is then supplied to the peripheral portion of the upper surface of the wafer W by flowing down on the outer wall surface 48 of the annular member 32. In order to introduce the etching liquid E flowing down on the outer wall surface 48 to the peripheral portion of the wafer W in a satisfactory manner, it is preferable to form the wafer-opposing surface 45 as an inclined plane that comes in close proximity to the upper surface of the wafer W as it heads toward the inside the wafer W.

The example of Fig. 9(e) is a case where an etching liquid supply path 105 is provided within the blocking plate 10 to allow a communication between the etching liquid supply path 105 and a discharge port that opens in the wafer-opposing surface 45 of the annular member 32. This arrangement makes it possible to supply the etching liquid E directly to the peripheral portion of the upper surface of the wafer W. In the case of the Fig. 9(e), the etching liquid supply path 105 is arranged in such a manner that it is inclined to head outwards as it nears the wafer-opposing surface 45 within the annular member 32, so that the etching liquid E is supplied to the

peripheral portion of the upper surface of the wafer W in a direction inclined toward the outside of the wafer W.

The example of Fig. 9(f) is the same as the arrangement shown in Fig. 4. That is, a liquid-receiving portion 107 is provided above the annular member 32 to receive the etching liquid E, and the etching liquid is supplied to the liquid-receiving portion 107 from an etching liquid supply nozzle 108 continuously or intermittently. The liquid-receiving portion 107 communicates with a discharge port that opens in the wafer-opposing surface 45.

The example of Fig. 9(g) shows a case where a liquid-receiving portion 110 that opens in the outer wall surface 48 of the annular member 32 is provided, and the etching liquid E from a nozzle 111 is supplied to the liquid-receiving portion 110 from the side. The liquid-receiving portion 110 communicates with a liquid supply path 112 formed within the annular member 32, and the liquid supply path 112 opens in the wafer-opposing surface 45.

The example of Fig. 9(h) shows a case where an etching liquid supply path 115 that opens in the wafer-opposing surface 45 and a liquid discharge path 116 that also opens in the wafer-opposing surface 45 are provided within the annular member 32. According to this arrangement, the etching liquid E is supplied through the etching liquid supply path 115 to a space between the wafer-opposing surface 45 and the

peripheral portion of the upper surface of the wafer W, while the etching liquid E is discharged through the liquid discharge path 116, which makes it possible to apply the etching processing to the peripheral portion of the upper surface of the wafer W while circulating the etching liquid E. According to this arrangement, because new etching liquid E is constantly supplied to the peripheral portion of the upper surface of the wafer W, the etching processing speed can be improved.

When the etching processing is performed in portions where a mound of the etching liquid E is placed in the peripheral portion of the upper surface of the wafer W while the wafer W is held at rest, it is preferable to supply the etching liquid E by any of the configurations shown in Fig. 9(c), Fig. 9(d), Fig. 9(e), Fig. 9(f), Fig. 9(g), and Fig. 9(h).

When the processing is performed while the wafer W is rotating in any of the configurations shown in Fig. 9(a), Fig. 9(b), Fig. 9(c), Fig. 9(d), Fig. 9(e), Fig. 9(f), Fig. 9(g), and Fig. 9(h), by supplying the etching liquid E toward the center of the lower surface of the wafer W concurrently as indicated by a chain double-dashed line, the processing to the lower surface of the wafer W can be performed in parallel.

In the embodiments described above, the gas nozzle 35 includes a continuous slit opening of a circular shape along the entire circumference. However, the gas nozzle 35 may include a plurality of gas discharge ports made in the

circumferential direction at intervals (for example at equiangular intervals) about the rotational axis of the wafer W. The discharge ports of the gas may be a circular hole or an arc-shaped oblong hole.

Also, in the embodiments described above, it is arranged in such a manner that the processing liquid will not be supplied to the central portion of the upper surface of the wafer W when the peripheral portion of the upper surface of the wafer W is processed. However, the central region of the wafer W may be covered with deionized water by opening the deionized water supply valve 15 while the peripheral portion of the upper surface of the wafer W is being processed, so that the central region is protected from the etching liquid. In order to protect the central region of the wafer W, etching protection liquid, such as carbonated water, hydrogenated water, returned water, ionized water, and magnetized water, can be used instead of deionized water.

It should be noted, however, that the etching protection liquid supplied to the central region of the wafer W gets mixed with and dilutes the etching liquid on the peripheral portion of the wafer W, and it is therefore preferable not to use the etching protection liquid when a reduction of a quantity of consumed etching liquid is desired.

In the embodiments described above, the spin chuck 1 arranged to clamp the peripheral end surface of the wafer W

was explained by way of example. However, a vacuum chuck that holds the wafer W by attracting the lower surface, and a roller chuck that rotates the wafer W by rotating while abutting on the end surface of the wafer W may be adopted. When the wafer W does not have to be rotated, a holding mechanism that moves the wafer W only spatially, or a fixed-type holding mechanism that holds the lower surface of the wafer W with a plurality of pins fixed to the ground surface may be adopted.

Also, in the embodiments described above, an explanation has been given to the processing of a semiconductor wafer, which is a substrate of a circular shape, by way of example. However, in the case of adopting the process of performing the processing by placing a mound of the etching liquid on the substrate, in particular, the invention is applicable to a rectangular substrate, such as a glass substrate for a liquid crystal display.

Fig. 10 is a view schematically showing an arrangement of a substrate periphery processing apparatus according to a fourth embodiment of the invention. The substrate periphery processing apparatus is an apparatus to perform processing that removes a metal thin film (for example, copper thin film) C formed on the device-forming surface and the peripheral surface of the wafer W, used as an example of a substrate, from unwanted portions, that is, the peripheral portion of the device-forming surface and the peripheral surface. The

substrate periphery processing apparatus is provided with a spin chuck 501 that rotates while holding the wafer W almost horizontally, a blocking member 502 placed in close proximity to the upper surface of the wafer W held by the spin chuck 501, and a nozzle 503 used to supply the etching liquid to the upper surface 523 of the blocking member 502.

The spin chuck 501 includes, for example, a spin shaft 511 placed almost vertically, and an attraction base 512 fixed to the top end of the spin shaft 511. The spin chuck 501 is arranged so as to hold the wafer W in a nearly horizontal posture by vacuum-attracting a device non-forming surface (lower surface) of the wafer W by exhausting air in an air intake path formed within the attraction base 512 while the wafer W is placed on the attraction base 512 with the device-forming surface facing upward. A rotational driving mechanism 513 including a motor or the like is coupled to the spin shaft 511, and by inputting a rotational force into the spin shaft 511 from the rotational driving mechanism 513 while the wafer W is being held by the attraction base 512 through attraction, the wafer W is rotated about the vertical axis line (the central axis line of the spin shaft 511) passing through the center or nearly the center of the wafer W.

The blocking member 502 includes a lower portion 502A shaped like a circular plate having a diameter slightly smaller than the diameter of the wafer W, and an upper portion 502B

shaped like a cone having one surface of the lower portion 502A as the bottom surface. The other surface 521 of the lower portion 502A is provided oppositely in parallel with the upper surface of the wafer W held by the spin chuck 501. In other words, the blocking member 502 includes a lower surface 521 of a circular shape slightly smaller than the outside shape of the wafer W, a side surface 522 rising upright or nearly upright from the periphery of the lower surface 521, and an upper surface 523 of a conical shape inclined to approach the axis line passing through the center of the lower surface 521 as it heads upward from the top end edge of the side surface 522. The blocking member 502 is thus formed in the shape of a rotational body using the axis line passing through the center of the lower surface 521 as the central axis line. The blocking member 502 is provided in such a manner that its central axis line agrees with the central axis line of the spin shaft 511.

Inside the blocking member 502 is formed a nitrogen gas supply path 524 along the central axis line of the blocking member 502. A nitrogen gas is supplied to the nitrogen gas supply path 524 from a nitrogen gas supply source outside of the drawing. The nitrogen gas supply path 524 communicates with an opening 525 made in the lower surface 521 of the blocking member 502 at the center, and a nitrogen gas supplied to the nitrogen gas supply path 524 is discharged through the opening 525 toward the central portion of the upper surface of the wafer

W held by the spin chuck 501.

A hydrophobic member 526 formed to have a trapezoidal cross section is embedded in the lower portion 502A of the blocking member 502 from below, and the lower surface of the hydrophobic member 526 forms the lower surface 521 of the blocking member 502. The hydrophobic member 526 is not exposed to the side surface 522 of the blocking member 502. The surface (at least the lower surface) of the hydrophobic member 526 is coated with fluororesin, which makes the lower surface 521 of the blocking member 502 as a hydrophobic surface having a hydrophobic property. On the other hand, the side surface 522 and the upper surface 523 of the blocking member 502 are made as hydrophilic surfaces having a hydrophilic property by increasing a surface roughness through sandblast treatment.

Herein, the lower surface 521 as the hydrophobic surface is set to have 60 degrees or greater as an angle of contact (when a droplet of deionized water adheres on a given surface, an angle produced between the droplet-adhering surface and the surface of the droplet) between the surface 521 and a droplet of deionized water. The side surface 522 and the upper surface 523 as the hydrophilic surfaces are set to have 10 degrees or less as an angle of contact between these surfaces and a droplet of deionized water.

Before the processing to the wafer W is started, the blocking member 502 is retracted far above so as not to

interfere with the transportation of the wafer W. Then, when the wafer W is transported by an unillustrated transporting robot and delivered to the spin chuck 501, the blocking member 502 is lowered to a position at which the lower surface 521 comes in close proximity to the upper surface of the wafer W while securing a predetermined interval.

Subsequently, the spin chuck 501 (that is, the wafer W) is rotated at a predetermined rotational speed, and a nitrogen gas is supplied toward the upper surface of the rotating wafer W through the opening 525 in the lower surface 521 of the blocking member 502. Because a space between the wafer W and the blocking member 502 is filled with the nitrogen gas thus supplied, it is possible to prevent the etching liquid and an atmosphere containing the etching liquid from entering this space from outside. This prevents the metal thin film C formed on the central portion (device-forming region) of the upper surface of the wafer W from undergoing unwanted etching processing.

Also, the etching liquid is supplied to the upper surface 523 of the blocking member 502 from the nozzle 503. The nozzle 503 is placed on the central axis line of the blocking member 502, and the etching liquid from the nozzle 503 is supplied uniformly in the vicinity of the apex of the upper surface 523 of the blocking member 502 (the cone-shaped region having the central axis line of the blocking member 502 at the center).

Because the upper surface 523 and the side surface 522 of the blocking member 502 are hydrophilic surfaces, the etching liquid supplied to the upper surface 523 of the blocking member 502 spreads and flows downward along the upper surface 523, and flows on the side surface 522 further downward. Because the lower surface 521 of the blocking member 502 is a hydrophobic surface, the etching liquid reaching the lower end edge of the side surface 522 does not come around to the lower surface 521, and instead it flows continuously and vertically downward from the entire circumference of the lower end edge of the side surface 522. Thus, as shown in Fig. 11, the etching liquid flowing down from the blocking member 502 forms a liquid wall having a cylindrical surface 504 in contact with the side surface 522 of the blocking member 502, while being supplied to a region A1 (region to be etched) outside an intersection line of the upper surface of the wafer W and the cylindrical surface 504. The etching liquid supplied to the upper surface of the wafer W is then forced toward the periphery of the wafer W by a centrifugal force induced from rotations of the wafer W, and flows down on the peripheral surface (end surface) of the wafer W from the periphery of the wafer W. The unwanted metal thin film formed on the region A1 of the upper surface and on the entire peripheral surface of the wafer W can be thus removed.

As has been described, according to this embodiment, the

etching liquid to be supplied to the peripheral portion of the upper surface of the wafer W is supplied to the upper surface 523 of the blocking member 502 from the nozzle 503 first, then flows on the upper surface 523 and the side surface 522 of the blocking member 502, and flows downward to the peripheral portion of the upper surface of the wafer W while forming a liquid wall having the cylindrical surface 504 that conforms to the side surface 522 of the blocking member 502. Because the upper surface 523 and the side surface 522 of the blocking member 502 are hydrophilic surfaces while the lower surface 521 is a hydrophobic surface, the etching liquid on the upper surface 523 or the side surface 522 of the blocking member 502 neither scatters outward nor comes around to the lower surface 521 of the blocking member 502 to fall on a region B1 (region not to be etched) where the metal thin film C needs to be left. The cylindrical surface 504 of the liquid wall formed by the etching liquid thereby intersects with the upper surface of the wafer W on a specific line. This eliminates variance in width (etching width) of the region A1 where the metal thin film C on the upper surface of the wafer W needs to be removed, and therefore makes it possible to control the etching width more accurately than a conventional apparatus. Further, it is also possible to prevent the etching liquid from entering the region B1 where the metal thin film C needs to be left.

In this embodiment, the blocking member 502 is held at

rest while the etching liquid is supplied to the wafer W. However, a rotational driving mechanism may be provided in association with the blocking member 502, so that the rotational driving mechanism rotates the blocking member 502, for example, about the central axis line of the blocking member 502, that is, coaxially with the rotational axis of the wafer W. By rotating the blocking member 502, a quantity of the flowing-down etching liquid can be made equal or nearly equal at the lower end edge of the blocking member 502 along the entire circumference. Even when the blocking member 502 is rotated, because the upper surface 523 and the side surface 522 of the blocking member 502 are hydrophilic and the lower surface 521 is hydrophobic, the etching liquid flowing down from the blocking member 502 flows downward to the peripheral portion of the upper surface of the wafer W while forming the liquid wall having the cylindrical surface 504 that conforms to the side surface 522.

Also, the wafer W is kept rotated while the etching liquid is supplied to the wafer W in this embodiment. However, the processing may be performed while the wafer W is held at rest. Even in this case, it is possible to prevent the supplied etching liquid from entering the central portion of the wafer W as long as a gas (nitrogen gas) is supplied through the opening 525 made in the lower surface 521 at the center.

Further, the blocking member 502 includes the lower

surface 521 of a circular shape slightly smaller than the outer shape of the wafer W in this embodiment. This is because the region (region not to be etched) B1 where the metal thin film C on the upper surface of the wafer W needs to be left is set in a region of a circular shape at the central portion of the wafer W, while the region (region to be etched) A1 where the metal thin film needs to be removed is set in an annular region surrounding the region not to be etched. That is to say, it is sufficient that the blocking member 502 includes a shape such that corresponds to the boundary dividing the region to be etched and the region not to be etched, at the lower end edge.

When the processing is performed while the wafer W is held at rest on the spin chuck 501 and the blocking member 502 is also held at rest, in order to remove the metal thin film formed on the upper surface of the wafer W through etching from an annular region in the peripheral portion and a region held by the hand H of the transporting robot (a region A2 to be etched), as shown in Fig. 12, for example, the boundary dividing the region A2 to be etched and a region B2 not to be etched may be set, and the lower surface (lower end edge) of a blocking member 505 may be formed into a shape corresponding to the boundary thus set. It should be noted that the lower surface of the blocking member 505 is a hydrophobic surface and the upper surface and the side surface of the blocking member 505

are hydrophilic surfaces in this case, too. In addition, in order to prevent the etching liquid from entering the region B2 not to be etched, a gas (nitrogen gas) is supplied through an opening 535 made in the lower surface (surface opposing the wafer W) of the blocking member 505 at the center.

Also, as shown in Fig. 13, a boundary dividing a region A3 to be etched and a region B3 not to be etched may be set linearly, so that a blocking member 506 includes a rectangular lower surface (hydrophobic surface), a side surface (hydrophilic surface) rising upright or nearly upright from the periphery of the lower surface, and a planar upper surface (hydrophilic surface) inclined downward as it nears the boundary.

Additionally, in order to prevent the etching liquid from entering the region B3 not to be etched, a gas (nitrogen gas) is supplied through a plurality of openings 545 made in the lower surface (surface opposing the wafer W) of the blocking member 506. The plurality of openings 545 are provided along the linear boundary dividing the region A3 to be etched and the region B3 not to be etched. Further, it is preferable that a direction in which the gas is blown out through the plurality of openings 545 is tilted at a specific angle, so that an airflow is developed above the upper surface of the wafer W in a direction heading to the region A3 to be etched from the region B3 not to be etched.

Further, according to the embodiment shown in Fig. 13, the wafer W may be rotated about the rotational axis that intersects at right angles with the wafer W by a substrate holding mechanism that holds the wafer W. When arranged in this manner, the region A3 to be etched can be an annular region in the peripheral portion of the wafer W. By setting the rotational axis of the wafer W to pass through the center of the wafer W, it is possible to give a substantially regular width to the annular region in the region A3 to be etched along the entire circumference of the wafer W. Alternatively, by setting the rotational axis of the wafer W away from the center of the wafer W, it is possible to vary the width of the annular region in the circumferential direction and thereby to obtain an eccentric annular region as the region A3 to be etched. When the wafer W is rotated as described above, a circular region about the rotational axis of the wafer W is obtained as the region B3 not to be etched.

Further, a nitrogen gas is supplied to a space between the wafer W and the blocking member 502 in the embodiments above. However, a gas to be supplied is not limited to a nitrogen gas, and other inert gases, such as a helium gas and argon gas, may be supplied as well.

Also, in the embodiments above, side surfaces are provided to the blocking members 502, 505 and 506. However, the blocking member may omit the side surface. In other words,

the upper surface and the lower surface of the blocking member may intersect directly on the end edge of the blocking member. It should be noted, however, that when accuracy as to the shape of the region to be etched needs to be improved, it is preferable to provide a side surface, in particular, a vertical side surface, as was described in the embodiments above.

The embodiments above described the processing that removes an unwanted metal thin film formed on the wafer W with the use of the etching liquid as an example of the processing applied to the region subject to processing of the wafer W. However, the processing applied to the region subject to processing of the wafer W may be peripheral-portion rinsing processing that rinses the peripheral portion of the wafer W with rinsing liquid, or alternatively, it may be resist removing processing that removes an unwanted resist film formed on the wafer W with the use of resist removing liquid.

The substrate subject to processing is not limited to the wafer W, and it may be substrates of other kinds, including a glass substrate for a liquid crystal display, a glass substrate for a plasma display panel, a glass substrate for a photomask, etc.

Fig. 14 is a view schematically showing an arrangement of a substrate processing apparatus according to a seventh embodiment of the invention. The substrate processing apparatus is an apparatus that removes an unwanted metal thin

film formed on the peripheral portion of the device-forming surface, the back surface, and the peripheral surface (end surface) of the wafer W used as an example of a substrate. The substrate processing apparatus includes a spin chuck 601 that rotates while holding the wafer W almost horizontally, and an opposing member 602 placed oppositely in close proximity to the upper surface of the wafer W held by the spin chuck 601.

The spin chuck 601 includes a motor 611 installed with its driving shaft aligned along the vertical direction, a spin base 612 attached horizontally to the top end of the driving shaft of the motor 611, and a plurality of clamping members 613 provided on the spin base 612. The plurality of clamping members 613 are placed along the circumference corresponding to the outer shape of the wafer W, and are able to hold the wafer W almost horizontally by clamping the wafer W at a plurality of different positions on the circumferential surface. By driving the motor 611 while the wafer W is held, the wafer W is rotated about the vertical axis line passing through the center or nearly the center of the wafer W.

The driving shaft of the motor 611 comprises a hollow shaft, into which is inserted a back-surface processing nozzle 614 selectively supplied with the etching liquid and deionized water. The back-surface processing nozzle 614 includes a dispense port at a position in close proximity to the center of the lower surface (back surface) of the wafer W held by the

spin chuck 601, and has a configuration of a central axis nozzle that supplies deionized water or the etching liquid toward the center of the lower surface of the wafer W through the dispense port.

An arm 621 that extends almost horizontally is provided above the spin chuck 601, and the opposing member 602 is held rotatably by a holding tubular member 622 hanging from the tip end portion of the arm 621, and is placed in such a manner that its rotational axis line agrees with the rotational axis line of the wafer W. Also, an elevator driving mechanism 623 that moves the opposing member 602 upward/downward is provided in association with the arm 621. The opposing member 602 is retracted far above when the wafer W is transported in or out from the spin chuck 601 so as not to interfere with the incoming/outgoing transportation of the wafer W, and is lowered to a position in close proximity to the upper surface of the wafer W when the wafer W is processed. Also, a rotational driving mechanism 624 used to rotate the opposing member 602 is provided in association with the arm 621, and the opposing member 602 is rotated in the same direction as the wafer W when the wafer W is processed.

The opposing member 602 is provided with a nitrogen gas supply path 625 along the rotational axis line, to which a nitrogen gas is supplied from a nitrogen gas supply source. The nitrogen gas supply path 625 opens in the lower surface

of the opposing member 602 at the center, and a nitrogen gas supplied to the nitrogen gas supply path 625 is discharged through the opening toward the center of the upper surface of the wafer W held by the spin chuck 601.

The opposing member 602 includes a cone portion 627 having a bottom surface (lower surface) 627A of a circular shape with a diameter slightly smaller than the diameter of the wafer W and a conical plane 627B inclined to move away from the rotational axis line of the opposing member 602 as it heads downward, and a ring-shaped projection 628 formed in the peripheral portion of the bottom surface 627A of the cone portion 627 along the entire circumference. The bottom surface 627A of the cone portion 627 forming the lower surface of the opposing member 602 and the lower surface 628A of the projection 628 are both nearly parallel to the upper surface of the wafer W held by the spin chuck 601 and oppose each other. An outer side surface (outer peripheral surface) 628B of the projection 628 forming the side surface of the opposing member 602 is a cylindrical surface along the vertical direction. The outer side surface 628B and the conical plane 627B of the cone portion 627 forming the upper surface of the opposing member 602 are connected smoothly, for example, through a rounded plane having an arc-shaped convex-curved cross section. The opposing member 602 arranged in this manner is formed by applying cutting treatment to a mold part made of resin, such

as vinyl chloride resin and fluorine-based resin. This provides a surface roughness sufficient to remain hydrophilic to the conical plane 627B of the cone portion 627 and the lower surface 628A and the outer side surface 628B of the projection 628.

An upper surface nozzle 603 is attached to the tip end of the arm 621, to which the etching liquid is supplied from the etching liquid supply source. When the etching processing is performed to the wafer W, the etching liquid is supplied to the vicinity of the uppermost portion of the conical plane 627B of the opposing member 602 from the upper surface nozzle 603 while the wafer W is held by the spin chuck 601 with its device-forming surface facing upward, and both the wafer W and the opposing member 602 placed in close proximity to the upper surface of the wafer W are rotated at their respective specific speeds. Because the conical plane 627B and the outer side surface 628B and the lower surface 628A of the projection 628 are rough surfaces having a hydrophilic property, and the conical plane 627B is connected to the outer side surface 628B of the projection 628, the etching liquid supplied to the vicinity of the uppermost portion of the conical plane 627B flows down on the conical plane 627B and the side surface 628B, part of which comes around to the lower surface 628A from the side surface 628B and flows down from the lower surface 628A to the peripheral portion of the upper surface of the wafer

W.

Because the bottom surface 627A of the cone portion 627 is formed at a position higher than the lower surface 628A of the projection 628, the etching liquid having reached the inner periphery of the lower surface 628A by flowing on the lower surface 628A flows downward vertically from the inner periphery of the lower surface 628A without going around to the bottom surface 627A side. The etching liquid supplied to the upper surface of the wafer W from the opposing member 602 is thus supplied to a peripheral portion region A outside the intersection line of the cylindrical surface containing the inner periphery of the lower surface 628A and the upper surface of the wafer W, and will not be supplied to the region (device-forming region) inside the intersection line.

Meanwhile, when the etching processing is performed to the wafer W, the etching liquid is supplied from the back-surface processing nozzle 614 to the center of the lower surface of the rotating wafer W. The etching liquid supplied to the center of the lower surface of the wafer W flows toward the periphery by flowing on the lower surface of the wafer W, part of which comes around to the end surface of the wafer W. As shown in Fig. 15, the peripheral portion region A of the upper surface, the back surface, and the peripheral surface of the wafer W are thereby covered with a flow of the etching liquid, and an unwanted metal thin film formed on the peripheral

portion region A of the upper surface, the lower surface, and the peripheral surface of the wafer W is removed by the etching liquid.

Also, while the etching liquid is supplied to the wafer W (while the etching processing is performed), a nitrogen gas is kept supplied toward the center of the upper surface of the wafer W from the nitrogen gas supply path 625 in the opposing member 602. Because a space between the wafer W and the opposing member 602 is filled with the nitrogen gas thus supplied, entrance of the etching liquid and an atmosphere containing the etching liquid into this space from outside can be prevented. It is thus possible to prevent the metal thin film formed on the device-forming region of the upper surface of the wafer W from undergoing unwanted etching processing.

The rotational speed of the wafer W during the etching processing is set to a constant speed, for example, within a range from 150 to 350 rpm, and the rotational speed of the opposing member 602 is set to be 50 rpm lower than the rotational speed of the wafer W. By setting the rotational speed of the opposing member 602 lower than the rotational speed of the wafer W, it is possible to prevent the etching liquid on the opposing member 602 from being scattered by a centrifugal force while making it easier for the etching liquid to come around to the peripheral portion region A of the wafer W. In order to prevent backlash of the etching liquid on the opposing member 602, a

flow rate of the etching liquid to be supplied from the upper surface nozzle 603 to the upper surface of the opposing member 602 is set to 0.1 to 0.5 liter per minute.

When the etching processing continues for a certain time, a supply of the etching liquid from the upper surface nozzle 603 and the back-surface processing nozzle 614 is stopped, and instead a supply of deionized water is started from the upper surface nozzle 603 and the back-surface processing nozzle 614 to the peripheral portion region A of the upper surface of the wafer W and the lower surface of the wafer W. The wafer W is kept rotated by the spin chuck 601 after the supply of deionized water is started. Deionized water from the upper surface nozzle 603 flows on the upper surface of the opposing member 602 to be supplied to the peripheral portion region A of the upper surface of the wafer W, and flows down on the peripheral surface of the wafer W. Deionized water supplied to the center of the lower surface of the wafer W from the back-surface processing nozzle 614 is forced to flow on the lower surface of the wafer W toward the periphery by a centrifugal force induced by rotations of the wafer W. Deionized water is thereby supplied across the region where the etching liquid has been supplied during the etching processing, that is, across the peripheral portion region A of the upper surface, the lower surface, and the peripheral surface of the wafer W, and the rinsing processing that washes away the etching liquid

adhering to the wafer W is thus achieved. During this rising processing, deionized water supplied from the upper surface nozzle 603 also washes away the etching liquid that adhered to the upper surface of the opposing member 602 during the etching processing.

When the rinsing processing continues for a certain time, the supply of deionized water from the upper surface nozzle 603 and the back-surface processing nozzle 614 is stopped. Then, the rotational speeds of both the wafer W and the opposing member 602 are increased, and drying processing is performed, by which droplets adhering on the surface of the wafer W are thrown off by a centrifugal force. During the drying processing, the opposing member 602 is rotated almost as fast as the wafer W in the same direction. Also, a nitrogen gas is supplied to a space between the wafer W and the opposing member 602 from the nitrogen gas supply path in the opposing member 602. This gives rise to a stable airflow of a nitrogen gas in the space between the wafer W and the opposing member 602, and the wafer W can be dried in a satisfactory manner without leaving any trace of deionized water on the surface of the wafer W.

As has been described, according to this embodiment, during the etching processing of the wafer W, the etching liquid is supplied to the conical plane (upper surface) 627B of the opposing member 602 from the upper surface nozzle 603, and the

etching liquid supplied to the conical plane 627B flows on the conical plane 627B and the side surface 628B, and is supplied to the peripheral portion region A of the upper surface of the wafer W from the lower surface of the projection 628 provided on the lower surface of the opposing member 602. It is thus possible to supply the etching liquid to the peripheral portion region A of the upper surface of the wafer W regardless of whether the surface of the wafer W is hydrophobic or hydrophilic.

The etching liquid supplied to the upper surface of the wafer W from the opposing member 602 is supplied only to the peripheral portion region A outside the intersection line of the cylindrical surface containing the inner periphery of the lower surface 628A of the projection 628 and the upper surface of the wafer W, and will not be supplied to the region inside the intersection line. It is thus possible to control accurately the etching width (a width of the peripheral portion region A to which the etching processing is applied) of the upper surface of the wafer W depending on the width of the projection 628.

In the embodiment above, the rotational speed of the opposing member 602 during the etching processing is set to be 50 rpm lower than the rotational speed of the wafer W. However, in order to prevent the etching liquid on the opposing member 602 from being scatted by a centrifugal force, the

rotational speed of the opposing member 602 during the etching process may be set to a further lower rotational speed (for example, 30 rpm). Alternatively, in order to ensure the prevention, the opposing member 602 may be held at rest during the etching processing.

Also, in the embodiment above, a rough surface (hydrophilic surface) having a hydrophilic property is provided to the conical plane 627B of the opposing member 602, etc. by forming the opposing member 602 from a mold part made of vinyl chloride resin through cutting treatment. However, the opposing member 602 may be formed through cast treatment, so that sandblast treatment is applied to the conical plane 627B and the lower surface 628A and the outside surface 628B of the projection 628 to make these surfaces as rough surfaces having a hydrophilic property.

Also, the lower surface 628A of the projection 628 is made as a plane placed oppositely almost in parallel with the upper surface of the wafer W held by the spin chuck 601. However, as shown in Fig. 16, the lower surface 628A of the projection 628 may be formed as an inclined plane having a cross section inclined linearly so as to near the wafer W as it approaches the rotational axis line of the opposing member 602. Alternatively, as shown in Fig. 17, the lower surface 628A and the outer side surface 628B of the projection 628 may be formed as an inclined plane (rounded plane) having an almost

arc-shaped cross section (convex-curved cross section). By adopting the arrangement shown in Fig. 16 or Fig. 17, the etching liquid is allowed to come around to the lower surface 628A in a satisfactory manner, and a larger quantity of the etching liquid can be supplied to the peripheral portion region A of the upper surface of the wafer W.

Further, as shown in Fig. 18, a groove 291 may be provided in the lower end edge portion of the conical plane 627B of the opposing member 602 together with a communication path 292 that allows a communication between the groove 291 and a space below the lower surface 628A of the projection 628, so that the etching liquid supplied to the conical plane 627B of the opposing member 602 is supplied to the peripheral portion of the upper surface of the wafer W from the groove 291 through the communication path 292. The etching liquid supplied to the conical plane 627B of the opposing member 602 not only passes through the groove 291 and the communication path 292, but also comes around the side surface 628B to the lower surface 628A to be supplied to a gap between the lower surface 628A and the upper surface of the wafer W as with the embodiment above. It is thus possible to supply a larger quantity of the etching liquid to the peripheral portion region A of the upper surface of the wafer W in a more reliable manner.

Also, in the embodiment above, the ring-shaped projection 628 is formed in the peripheral portion of the bottom

surface 627A of the conical plane 627 along the entire circumference. However, as shown in Fig. 19, the projection 628 may be formed in the shape of an arc (a shape that conforms to at least part of the outer shape of the substrate subject to processing) in part of the peripheral portion of the bottom surface 627A of the cone portion 627. In this case, the opposing member 602 is not rotated, and instead the wafer W alone is rotated during the etching processing of the wafer W. Also, it is preferable that the etching liquid is supplied from the upper surface nozzle 603 onto the line linking the center of the projection 628 and the rotational axis line of the opposing member 602, so that the etching liquid flows toward the arc-shaped projection 628.

Further, the processing that removes an unwanted metal film formed on the wafer W with the use of the etching liquid was described as an example of the processing applied to the wafer W. However, the processing applied to the wafer W may be peripheral-portion rinsing processing that rinses the peripheral portion of the wafer W with rinsing liquid, or alternatively, it may be resist removing processing that removes an unwanted resist film formed on the wafer W with the use of resist removing liquid.

The substrate subject to processing is not limited to the wafer W, and it may be substrates of other kinds, including a glass substrate for a liquid crystal display, a glass

substrate for a plasma display panel, a glass substrate for a photomask, etc.

While the above description described embodiments of the invention in detail, it should be appreciated that these embodiments represent examples to provide clear understanding of the technical contents of the invention, and the invention is not limited to these examples. The sprit and the scope of the invention, therefore, are limited solely by the scope of the appended claims.

This application is based on Application Nos. 2002-240891, 2002-283458, and 2002-346179 filed with the Japanese Patent Office respectively on August 21, 2002, September 27, 2002, and November 28, 2002, the entire contents of which are incorporated hereinto by reference.